Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VIII. NEW YORK, JANUARY, 1904. No. 11.

"Compressed Air,"

OR

THE COMPRESSED AIR MAGAZINE.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

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Subscription, including postage, United States, Canada and Mexico, $1.00 a year. All other countries, $1.50 a year. Single copies, 10 cents.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

All communications should be addressed to COMPRESSED AIR, 26 Cortlandt St., New York.

London Office, 114 Queen Victoria Street.

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Entered as Second-Class Matter at the New York, N. Y., Post Office.

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The Pennsylvania Tunnel.

Without doubt the largest undertaking ever attempted with the assistance of compressed air is the building of the system of tunnels by which the trains of the Pennsylvania Railroad will enter the City of New York and connect with the Long Island Railroad in Brooklyn. Bids for the construction of these tunnels were opened December 15, and by the time this issue appears it is probable that the contracts will have been awarded.

The specifications provide that, unless the bidders can submit some other means which will accomplish the desired end more economically, the tunnels be driven by the shield method, which has already proven very successful in smaller subaqueous tunneling enterprises. The general belief is, however, that the tunnels will be built in the same fashion as are those of the Hudson Improvement Company under the Hudson River and the New York Tunnel Company under East River, full descriptions of which have already been published in COMPRESSED AIR.

If the specifications are followed the contractors will be operating the shields and compressed air locks in sixteen different headings at the same time. Under the Hudson River there are to be two tubes, each of which will be started simultaneously from both ends. They will require four headings. Four tunnels are to be built under the East River and these will be driven from both ends at the same time. Four more headings are called for on the Long Island side, as an examination has shown that the material for a distance of 1,600 feet east of the main shaft is very soft.

This marked increase in this class of work will result in a demand for laborers acquainted with this method of tunneling. While the high wages paid and the short hours required will undoubtedly attract many men, it will be very difficult to secure experienced and capable foremen. One of the most important requisites will naturally be a thorough knowledge of compressed air and compressed air machinery. This will have a strong tendency to encourage the workmen to look more fully into this form of power transmission and will exert a powerful influence on future undertakings of this nature.

A departure has been made in the means designed for the support of the tunnel tubes on the bed of the river. The engineers, who prepared the specifications, have decided in favor of a series of hollow iron tubes or piers which must be sunk from the headings as they progress and driven to a firm foundation. These tubes will be 27 inches in diameter and 12½ feet apart and will be filled with cement. The sinking of these tubes of uncertain length offers a new problem to be considered.

As this is one of the most important events of the year in which compressed air has figured, it will be the aim of this publication to keep its readers in close touch with the progress being made. In addition to keeping pace with the general advancement of the enterprise, we are planning to publish a series of papers dealing with the problems encountered during the construction of the tunnels.

Compressed Air for Tunneling.

The adaptability of compressed air for tunneling under a wide variety of conditions has been signally demonstrated in the construction of the Rapid Transit Subway for New York City. Where the excavation consists simply of boring a hole through the solid rock, we find compressed air used to drive the rock drills. In the open tunnel or ditch we find compressed air supplying the power for driving sheeting as well as supplying the rock drills. In the tunnels under the Hudson and East Rivers the shield method operating under air pressure has proved itself the only successful method for that particular line of subaqueous work. Now the Rapid Transit Subway contractors have found another means of utilizing it in building the tunnel under the Harlem River.

It was desirable to keep the tunnel under the Harlem River as near to the river bottom as possible so as to avoid the use of heavy grades in the tunnel approaches. The mud was, however, so thin that tunneling by the shield method was practically out of the question. A new plan was tried and with success. Two lines of sheet piling were driven parallel with the line of the tunnel and wide enough to enclose it. A strong roof of timber was constructed across from wall to wall of the piling. Then, by means of pneumatic pressure and air locks, the water and soft mud were excavated from within the tunnel caisson and the tunnel structure was constructed, partly of concrete and partly of cast-iron, within the working chamber thus provided.

Half of the tunnel was built at a time, so as not to interfere with navigation. A rectangular chamber caisson was built near the centre with the usual air locks. In this was placed the machinery for taking out the soft material of excavation. A pressure of ten pounds to the square inch was found sufficient. The leakage of air from under the roof during the work was very small. When the water had been lowered in the working chamber, the mud and other material was removed without any difficulty whatever. Then followed the construction of the tunnel itself.

Those who have watched this method of tunneling declare that it will be equally successful at any practicable depth at which it was desired to carry the excavation. Mr. McBean, one of the contractors who have been building the Harlem River tunnel, declares that this system can be used in tunneling the Hudson River, and that, owing to the fact that it would be possible to open the work at several points at once, this method would greatly expedite the work. In any event this serves to demonstrate the great value of compressed air for another method of subaqueous tunneling.

Compressed Air Locomotives for Mine Haulage.

To every mine superintendent who has charge of a growing mine must come sooner or later the problem of mechanical haulage, and the necessity of considering its installation at an early date.

With this idea in view, let us briefly go over the points to be taken care of, and consider the advantages to be gained in the event of the haulage being performed by compressed air locomotives.

To make the system of haulage a per-

fect one, and therefore keep down the cost per ton hauled as much as possible, every mule which heretofore has been in use should be supplanted, and the entire output collected and handled by locomotives.

The advantages to be gained by the adoption of this plan are important, and generally lead, if not always, to an increase in the tonnage, and to a decrease in the cost per ton.

We shall therefore assume that the installation contemplates the doing away with every mule now employed, and the using of the loomotives not only on the main and cross entries, but also in the chambers or rooms, for the purpose of gathering the loaded cars from the face and hauling them to the various partings or side tracks. Such being the case, the following natural conditions will have much to do with the adoption of compressed air as a motive power:

In all mines where fire damp or other dangerous gas is present in such quantities as to render the use of naked lights unwise or dangerous, more especially on the cross entries on which the working rooms are located, compressed air locomotives should be employed, as they may be used with perfect safety, and serve to mitigate any dangerous condition of this nature instead of increasing it.

In mines where the top or bottom are extremely wet, they may be operated with but little depreciation, as the working parts exposed are strong and of simple construction, and suffer but little from contact with the water.

When grades are severe, making the work of hauling the cars over them heavy, a compressed air locomotive may be overloaded far beyond its normal capacity and will remain uninjured, though this be done frequently.

In descending grades with a heavy trip, the air locomotive may be reversed and air admitted into the cylinders, thus assisting greatly the retarding effort produced by the application of the brake.

In the handling of light loads at slow speed, these engines may be used continuously without any detrimental effect, the amount of air consumed decreasing as the load and speed are decreased.

In the gathering of cars from the rooms they will be found very efficient, because of their flexibility, speed and hauling capacity. For service of this kind where the cars are small and the

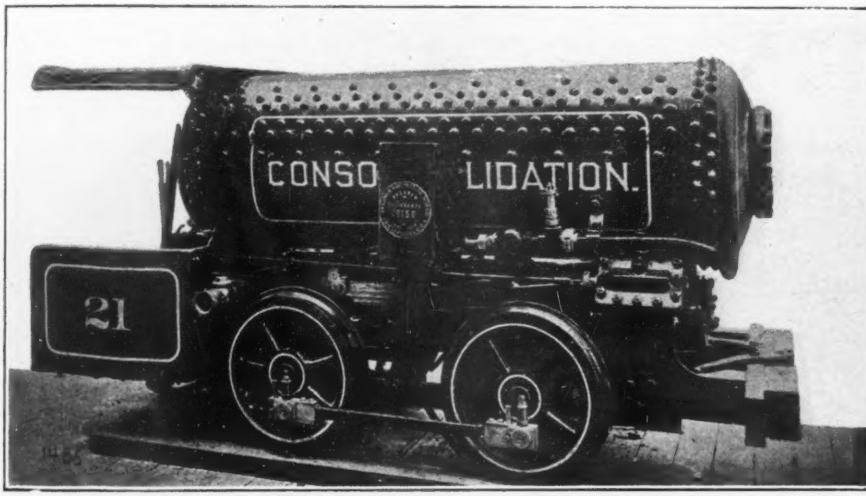


Fig. 1.

loads to be handled light, the locomotives may be operated on wooden rails should the necessity arise. While the cost of in-talling a compressed air plant may be somewhat greater than that of other mechanical haulage, the cost of extension amounts to very little. This is obvious for the following reasons: When the main pipe line has been laid, carrying sufficient volume and pressure to enable the locomotive to make its complete round trip with one charge of air, this distance may be increased several thousand feet by simply adding a second charging station placing it at the end of the line. The track to be used on the extension, after being laid, does not require any further outlay than would necessarily be incurred under usual conditions.

In the matter of repairs, the ease with which they can be made by almost anyone around a mine, in simpleness of construction and operation, the compressed air locomotive has many good points in its favor.

The illustrations show in Fig. 1 a room service locomotive built for the Consolidation Coal Co. and adapted for a track gauge of 3 feet. The cylinders are 5½ inches by 10 inches stroke, driving wheels 24 inches in diameter, wheel base 3 feet 2 inches. The storage capacity is provided for by one tank 31 inches inside diameter by 8 feet 3 inches in length, giving a volume of 40.5 cubic feet. The initial storage pressure is 900 pounds per square inch, the cylinder working pressure being 170 pounds per square inch. This locomotive is capable of traveling a distance of about 3,300 feet on one charge of air while exerting a tractive power of about 1,260 pounds, the point of cut-off being at one-half stroke. The over-all dimensions are: Height, 5 feet 3 inches; width, 4 feet 0 inches; length, 10 feet 0 inches; the weight in working order about 8,000 pounds.

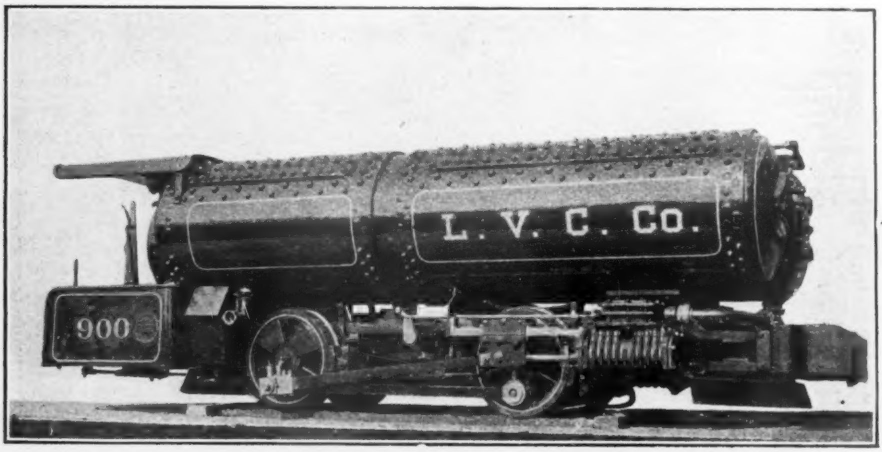


FIG. 2.

The locomotive illustrated in Fig. 2 is one constructed for the Lehigh Valley Coal Co., having been designed for main haulage work over a track of 3 feet gauge.

The principal dimensions of this machine are as follows: Cylinders, 9 inches by 14 inches; driving wheels, 26 inches in diameter; wheel base, 5 feet 6 inches. The storage requirements are provided for by two tanks, each having an inside diameter of 34 inches, the length being 14 feet and 16 feet 6 inches, respectively, giving a total capacity of 187 cubic feet. The initial storage pressure carried is 800 pounds per square inch, the cylinder

working pressure 140 pounds per square inch. The service requirements to be met call for the hauling of a train of cars weighing, including the load, approximately 65 tons, the final length of the round trip being 10,000 feet, the distance to be covered with one charge of air. The over-all dimensions are: Height, 5 feet 6 inches; width, 6 feet; length, 17 feet; the weight in working order being about 24,500 pounds.

Wisconsin University Water Works.

The proposed improvements and extension in the Wisconsin University water works consist in general of a system of tanks to furnish increased storage capacity.

Our present storage capacity is but 20,000 gallons, furnished by a large wooden tank in the attic of University Hall. This storage is too small to enable the supply to be satisfactorily maintained, especially during nights and Sundays.

The plans as now adopted and being carried out call for a storage system in which compressed air is used to maintain uniform pressure. There will be four tanks, circular in form and about 66 feet long and 8 feet in diameter. Two of these will be for water and two for air, the air tanks being placed above the water tanks and all of them in the plain brick building adjacent to the pump house. In the air tanks air will be maintained at a pressure of 100 to 150 pounds per square inch, and connecting the air tanks with the water tanks will be suitable pipes and regulating valves which will automatically introduce air into the water tanks and maintain pressure therein at about 75 pounds per square inch.

The present pumps will be operated as usual and will pump directly into these water tanks. Supposing these tanks to be full at night and the pumps not in operation, the water which is consumed will be drawn from these tanks, air being automatically introduced so as to maintain an even pressure. In the morning the pumps will be started and the water tanks again filled, and in the meantime the air that has accumulated in the water tanks will be drawn out by means of an air compressor and forced into the air tanks. The valves are so arranged that in case of fire air will be more rapidly admitted in the water tanks so as to increase the water pressure. The storage capacity of this plant will be 50,000 gallons.

The present pumps are two in number, each of about 500 gallons per minute capacity. The compressor will be duplex, single stage, of about 120 feet free air per minute capacity.

F. E. Turneaure,
Acting Dean, College of Engineers.

Raising Water with Compressed Air.*

This, like most all appliances for raising water, is not by any means a new invention. Papin, the great inventor of the safety valve for steam boilers, proposed to raise water by it. He said that if a closed vessel, furnished with a pipe at the bottom and filled with water, had air let into it under pressure on top of the water, the latter would pass out of the vessel to any height that may be required.

The application of compressed air to the raising of water in this country is, however, practically new, for until about six years ago we have no hesitation in saying that few had heard of the "Air-Lift Pump"; while to-day it may be found in use by scores of manufacturers, corporations, etc. It has come rapidly into use, because of its simplicity, as a means for raising water from deep wells, and is becoming popular because it affords a ready means of increasing the yield of wells that have begun to decrease in capacity.

There have been six methods employed in raising water by "Compressed Air":

1. Displacement apparatuses in which compressed air is employed at a constant pressure.
2. Displacement apparatuses in which the air is used expansively.
3. Direct-acting pumps in which a constant pressure is carried the whole length of the stroke.
4. Direct-acting pumps in which the compressed air is allowed to expand.
5. Air-lift pumps, single and combined with displacement chamber.

*By Philip R. Björling in the *Engineering Times*, London, Eng. Cuts published through the courtesy of the *Municipal Journal and Engineer*, in which it was republished.

6. Pumps operated by independent motors.

The principal reason why the compressed air method of raising water has not come to the front till recently is that air compressing has been very little studied practically, therefore, a great amount of loss in efficiency, hence great expense in working, and at the present time economy of power is a *sine qua non*. When a machine only gives an efficiency of 33 to 37 per cent. it is about time it was put on the shelf.

However, it is a very narrow view which takes in only the cost of fuel when on the same shed. Any increase in the number of wells generally affects the static pressure, but the quantity of the water cannot be determined by rules of watershed measurement, as applied to surface supplies, unless the areas and surfaces supplying the wells are already defined.

The cost of water pumping includes not only the cost of fuel, but the interest on the amount necessary to construct the plant, and to make a comparison on these lines the number of wells required to produce a certain amount of water should be figured for each system and

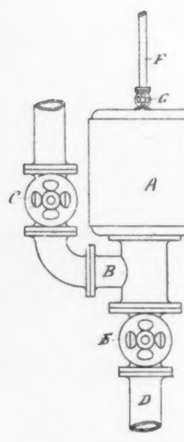


FIG. 1.

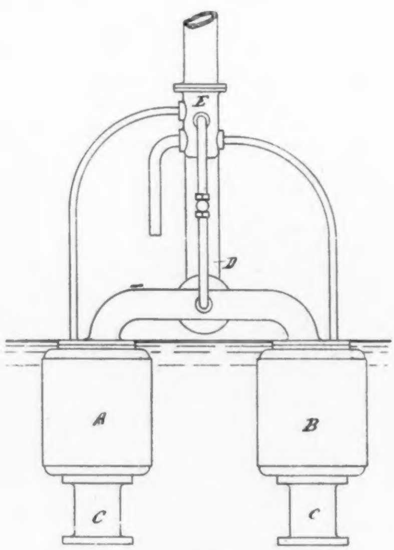


FIG. 2.

calculating the cost of pumping deep wells. The conspicuous feature in the air-lift pump is that it takes all the water a well can supply, whereas any mechanical pump only bales out a certain number of bucketfuls per minute, which experience shows is almost always less than the well can give, sometimes not over one-fifth of this.

The amount of underground water available in a well or group of wells is governed by the catchment area of source which supplies the stratum, modified by the medium through which the water circulates, and the number of wells the cost of the two plants of machinery and the interest on the two systems per year compared. This is an easy problem.

Another feature of the system, which can hardly be expressed in £ *s. d.*, but is no less important on that account, consists of the fact that the air lift has no working parts in the well. With any other system of deep well pumping occasional renewals for repairs must be made, and sooner or later something will break, leaving parts in the well which must be removed at an expense that cannot be calculated.

The great success in raising water by

compressed air depends upon proper proportions of the various pieces of machinery, sizes of the compressor and steam cylinders, and the proper areas of the steam, air, and water pipes. For instance, if we want to compress air to 200 to 300 pounds pressure per square inch, it does not pay to perform the compression in one cylinder, a two-stage compressor must be adopted; if we do not calculate the steam cylinder area properly, and do not apply a cut-off gear

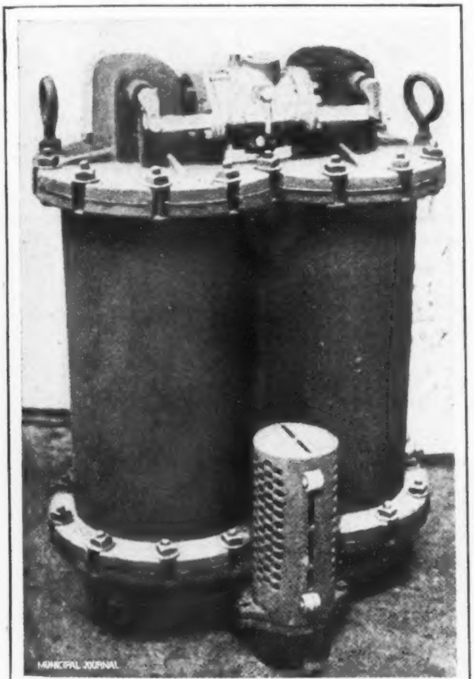


FIG. 3—"CHAPMAN" PATENT INLET OR PNEUMATIC PUMP.

for the steam engine, we will lose these again; another loss is given by too small pipes. What can we expect if we work a single cylinder engine at 100 pounds pressure per square inch, and compress the air in one cylinder to 300 pounds per square inch; and after that transmit the air to the air-lift pump by pipes so small that there is a loss of 20, 30, and even 50 per cent. by friction? That is frequently the state of affairs, and it is wondered why there is such a great amount of loss.

THE DISPLACEMENT APPARATUS IN WHICH COMPRESSED AIR IS EMPLOYED AT A CONSTANT PRESSURE.

Under this head comes the original idea of Papin. Take a tank or vessel, *A*, Fig. 1, of any description, provided with an outlet pipe, *B*, furnished with a cock, *C*, at the bottom, and a pipe, *D*, furnished with a cock, *E*, below, and another pipe, *F*, for admission of compressed air, also provided with a cock, *G*. Now, if we open the cock *C* and fill the vessel with water, turn off the cock *E*, and open the cocks *C* and *G*, admitting air under pressure through the pipe *F*, the water will be forced out of the delivery or outlet pipe, *B*, by the pressure of the air on the surface of the water in the vessel, similar to the action of the

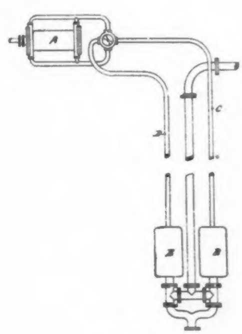


FIG. 4.

steam in the Pulsating Steam Pump. It will be clearly seen that in this case the air is exhausted into the atmosphere at the same pressure as it was admitted into the vessel *A*. An automatic double-acting air lift is illustrated in Fig. 2. It consists of two vessels or displacement cylinders, *A* and *B*, each being provided with a suction pipe, *C* and *C*. The cylinders are placed under the lowest water level or other source. *D* is a delivery pipe or rising main, connected, by means of a branch pipe, to the cylinders. *E* is an automatic valve which distributes the compressed air to the displacement cylinders. The action of this apparatus is precisely the same as Fig. 1, except that

it is double-acting, on account of the air being admitted alternately to the two cylinders by the automatic valve.

The last of this class of apparatus, the "Chapman" Patent Inlet or Pneumatic Pump, introduced into this country by the British-American Well Works, is shown in Fig. 3. This pump can be placed in a river, lake, or well, in any place of an ordinary pump for delivering and dirt proof, there being no stuffing-box to adjust or stop its action. It is provided with a large strainer, which prevents foreign substances entering. Its automatic switch, that switches the air from one cylinder to the other, is non-corrosive and balanced, requiring nominally no power to operate. It performs the service of a pump without pistons or working parts that are com-

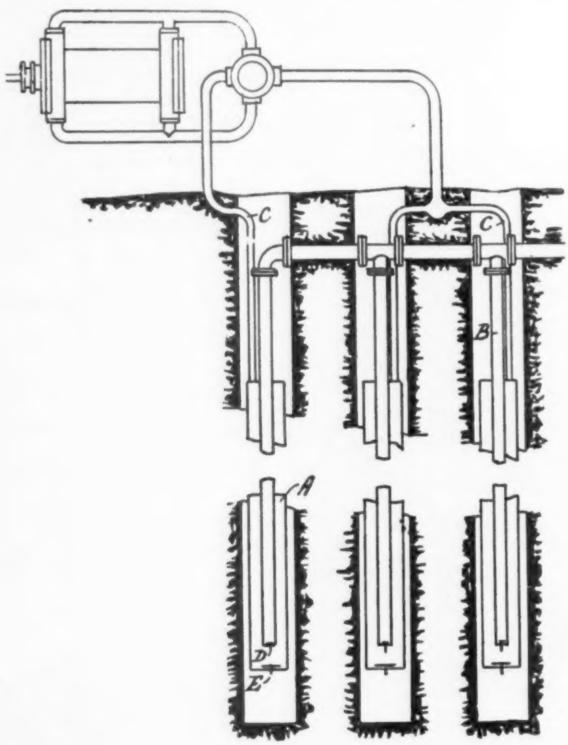


FIG. 5.

water any height or distance, by the application of air under pressure, miles if necessary from the engine that puts up the air pressure. It delivers a continuous stream of water. When one of the chambers is filling, the air is forcing the water from the other to its destination.

The automatic mechanism requires no oil or attention; being inside, it is sand monly worn. The air forms the piston, hence there is no wear. This apparatus will perform all the duties of moving water that a steam pump will, without loss by condensation. It will work successfully in water whose rise and fall may vary hundreds of feet. One gallon of air will bring the same amount of water a short distance, allowing ⅝ pound of air pressure for each foot of lift.

DISPLACEMENT APPARATUS IN WHICH THE AIR IS USED EXPANSIVELY.

This class of installation consists of two cylinders placed in the well or other source. The cylinders are, as in the previous examples, furnished with suction and delivery and air pipes. On the ground is fixed a double-acting air compressor and an automatic distributing valve. This arrangement is shown diagrammatically in Fig. 4. The action of the pump is as follows: As the automatic valve is shown in the diagram the air is passing from the right-hand end of the air cylinder, *A*, is in direct communication with the pump cylinder, *B*, through the pipe, *C*, and the suction or admission end of the air-compressor cylinder (the left-hand side of the piston) is through the pipe, *D*, in direct communication with the pump cylinder, *E*, so that the water is forced out of the water cylinder, *B*, up the rising main, and the air being drawn out of the pump cylinder, *E*, by the air-compressor piston, the water will rise up the suction pipe and fill the cylinder ready for being forced out when the automatic distributing valve changes its position, when the operation is reversed.

It is natural that if there are a number of wells or a number of water cylinders in each well, the air pipes can be so arranged that each end of the air-compressor cylinder can be connected with any number of water cylinders, although there ought to be the same number of cylinders for each end of the air compressor.

The "Harris" system, manufactured by the Pneumatic Engineering Company, of New York, is illustrated in Fig. 5. and shows a similar arrangement in which there are three wells worked by one single air compressor. In this the water cylinder, *A*, is very long and small in diameter, and the delivery pipe, *B*, passes nearly to the bottom of the water cylinder, and the compressed air pipe, *C*, is admitted into the top cover. Both the delivery pipe and the bottom of the cylinder are provided with valves, *D* and *E*, the former being the delivery and the latter the suction valves. The tank or cylinders are, of course, proportioned according to the capacity of the well.

Another arrangement is shown in diagram, Fig. 6. In this case the two water cylinders are placed at different levels, one delivering from the bottom of the well, *A*, to a sump, *B*, at a higher level, from whence cylinder *C* forces the water on the ground level. This arrangement can, of course, be multiplied to any desired extent. The air compressor and switch valve is the same as in previous examples.

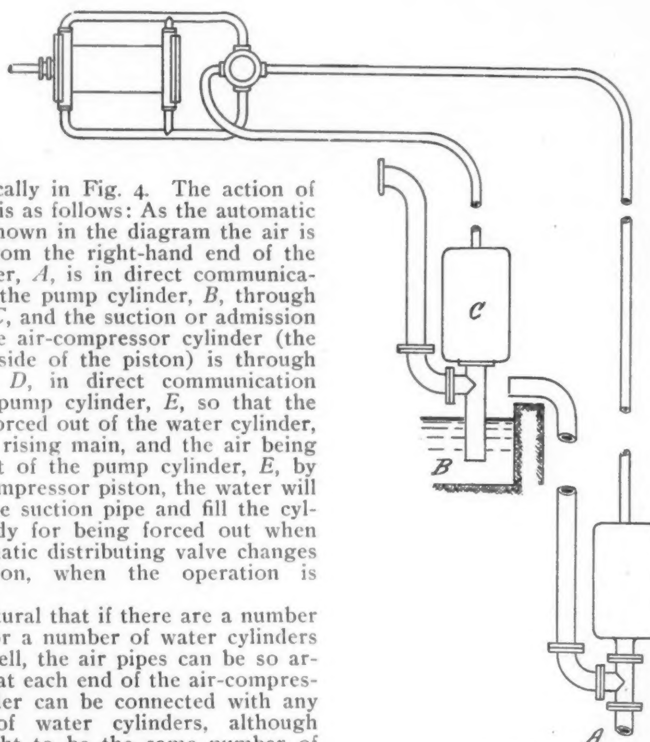


FIG. 6.

Direct-acting pumps, methods 3 and 4, are so well known and do not come

within the scope of this short article, therefore we must leave them for another article or to some other writer.

AIR-LIFT PUMPS, SINGLE AND COMBINED, WITH DISPLACEMENT CHAMBERS.

A sectional elevation, Fig. 7, shows one example of this class of air lift. It consists of a number of chambers (two

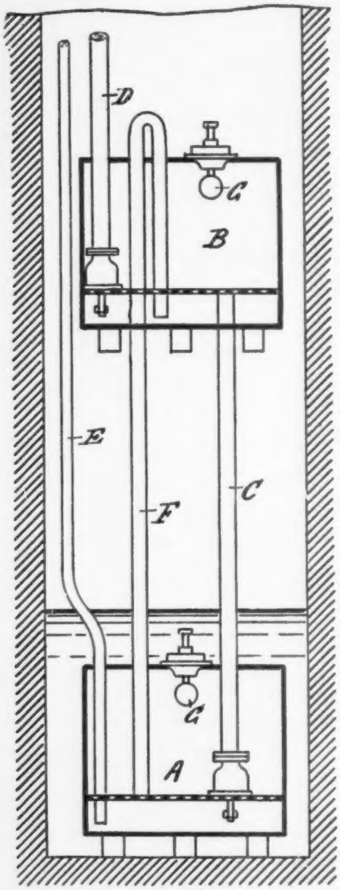


FIG. 7.

are shown in the illustration); *A* and *B* are the two chambers, the bottom one being submerged in the well, sump, or other source. *C* is the discharge pipe from the bottom chamber, and *D* the pipe from the second chamber to the ground, or to the chamber above it if there are three lifts. *E* is the air-compressor pipe to the bottom chamber, and *F* the air pipe between the chambers. *G* is a check valve in each tank which opens and puts the tank in communication with the atmosphere whenever the pressure falls to that of the atmosphere inside the tank, and immediately closing when the water rises up against it. Now, if the bottom tank, *A*, is full of water and the air is admitted, the water will be displaced and forced into the tank, *B*, but when the water is discharged from *A*, and just before the delivery pipe, *C*, is uncovered, the end of the air pipe, *E*, is uncovered, and passed up into the chamber, *B*, expanding against the water, and forces it up into the next chamber or any other source.

THE "WHEELER" AIR LIFT.

This device is shown in Fig. 8. *A* is a displacement chamber, *B* the delivery pipe or raising main, *C* the delivery valve, *D* compressed air pipe, and *E* a small air pipe, opening an air connection for the bottom of the delivery pipe. In this case the displacement is permitted to take place with low pressure, and this adds to the efficiency of the apparatus.

PUMPS OPERATED BY INDEPENDENT MOTORS.

We now come to the last class, which is no doubt the best, simplest, and cheapest if properly designed.

It is a peculiar feature of artesian wells that the conditions of no two are alike, and when this is borne in mind it will readily be understood that each well represents a problem requiring a special study.

Some makers of the air-lift pumps, to the detriment of the system, always recommend them, even when they are convinced that they are not suitable.

THE THEORY OF THE AIR-LIFT PUMP

Is best explained by reference to Fig. 9. If an open pipe, *A B*, is sunk in a vertical body of water and air is forced into its lower end, experiments have shown that the water will be raised in the pipe; the entering air current by its friction against the water carries it. It has also been found that when the air is not forced into the bottom of the pipe, but is merely allowed to escape, the water is raised in the pipe. The rise of water in the pipe is due to the lessened weight in

the pipe due to the space occupied by the air bubbles. Thus, suppose the pressure at the mouth of the pipe *A B* due to the head of water outside to be 6 pounds per square inch. Now, if the air bubbles inside the pipe *A B* occupy one-third the space, and the water occupies two-thirds the space, then the pressure at the mouth of the pipe *A B* due to the weight of water inside it will be only 4 pounds per square inch. Of course, the water hand, if we go to the other extreme, and pass in air bubbles so large that they completely fill the bore of the pipe, then you will have alternate layers of air and water, as in the pipe *C D*. In this case, again, the water at the top of the pipe is shut off from communication with the lower end and cannot exert the full hydrostatic pressure there, due to its elevated position.

Mr. Joseph F. Frizell patented an air-

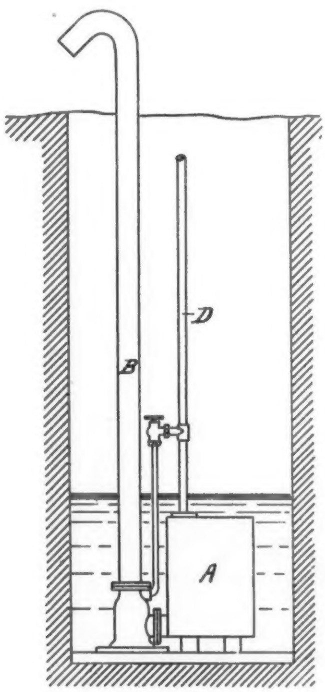


FIG. 8.

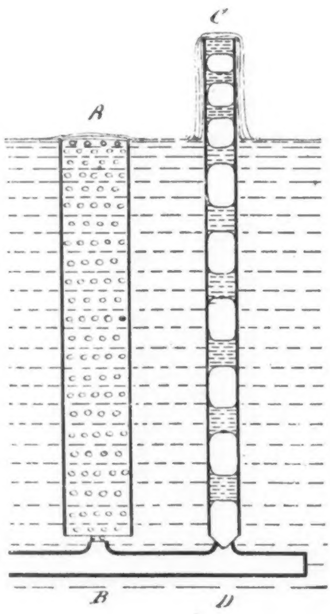


FIG. 9.

will rapidly flow into the pipe under these circumstances. Supposing the bubbles of air in the pipe are very small, so that they cannot rise freely through the water, we have really a mixture of the fluid. The specific gravity will be less than that of the water outside, and the water will rise because the interstices between the bubbles are too small for the water to flow down between them and exert its full head; or, on the other lift pump in America in the year 1878. It is illustrated in Fig. 10, and was arranged in the following manner: *A* is a dam which causes a difference of level in the water above and below it. *B* is a descending shaft, with the curb *C*, built up around the mouth. The water enters the shaft *G* over a wear and is thrown into a commotion which impregnates it with air bubbles. These are carried to a sufficient depth to ensure the required

pressure. In the horizontal port, *D*, of the passage, the air rises and enters the chamber *F*, and is drawn off through the pipe *H*. The water freed from air rises and returns to the stream below the dam through the ascending shaft.

Dr. Siemens invented an air-lift pump while sinking a mining shaft in the neighborhood of Berlin. The shaft was put down by the "Petsch" freezing process through about 100 feet of quicksand, but the ice melted before the sides were made watertight, and the shaft was water was recommended by Loescher, of Freiberg, in a pamphlet published in 1797; but it does not appear to have been tried, except in laboratory experiments.

"The idea of such a lift (air-lift pump) is not a new one," says Professor W. H. Echols, in a paper read by him before the Philosophical Society at the University of Virginia. In "Collen's Lecture on Mining," delivered at the School of Mines, in Paris, in his description of Trigard's method of sinking a mining shaft through very aquiferous strata at

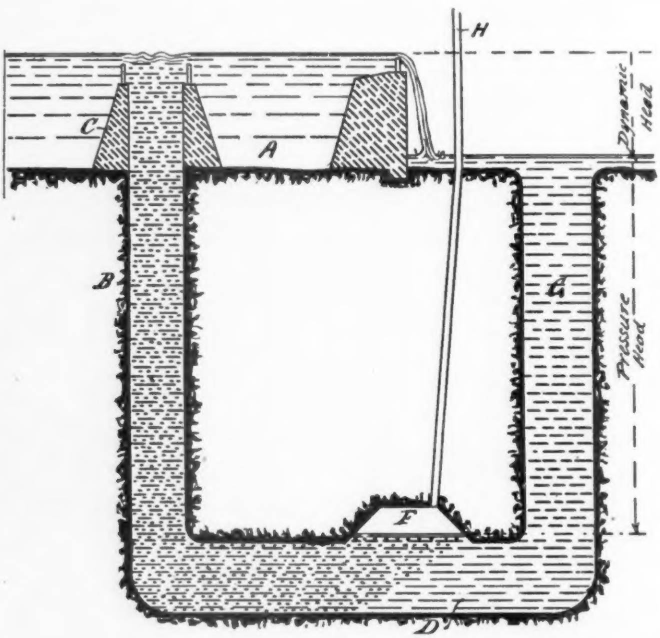


FIG. 10.

drowned out. It was attempted to stop the flow into the shaft by putting down numerous driven wells round the shaft; but these were so small in size that it was difficult to pump from them. It occurred to Dr. Siemens, therefore, to imitate the action of gas springs, geysers and flowing oil wells by conveying compressed air to the bottom of the well casing. The German paper *Zeitschrift des Vereins Deutscher Ingenieure,* in 1885 pointed out that this system of lifting Chalonnes, by means of a pneumatic cylinder, he gives the following design for expelling water and sand from the lower compartment: "The mixture of air and water in a vertical pipe forms a kind of froth having a less density than water, thus allowing it to be raised to the surface, where it flows out."

THE "POHLE" AIR-LIFT PUMP.

Manufactured by the Ingersoll-Sergeant Company, is made in three distinct

methods of well piping, each different from the other, and yet working on the same principle.

Method No. 1, Fig. 11, consists of placing the air and water pipes alongside of one another in the well, connecting them at the bottom with an end pipe.

Method No. 2, Fig. 12, consists of placing a water delivery pipe into the well, the air passing down into the well through the annular space between the well casing and the water pipe.

Method No. 3, Fig. 13, consists of using the well as the water delivery pipe and simply putting an air pipe down into the well with a special device attached to the bottom through which the air escapes.

The two properly proportioned pipes are placed in position. The compressed air is forced through the air pipe into the foot piece and water pipe, and by its inherent expansive force, layers or pistons of air are formed in the water pipe, which lifts and delivers the layers of water through the end of the water delivery pipe at the surface, or a tank.

At the beginning of the operation, the water surface of the pipe and the water surface inside the water pipe are at the same level; hence the vertical pressures per square inch are equal at the submerged end of the pipe, outside and inside. As the compressed air is forced into the lower end of the water pipe, it forms alternate layers with the water, so that the pressure per square inch of the column thus made up of air and water, as it rises inside of the water pipe, is less than the pressure per square inch outside of the water pipe. Owing to this difference of pressure, the water flows continually from the outside to within the water pipe by gravity, and its ascent through the pipe is free from shocks, jar, or noise of any kind.

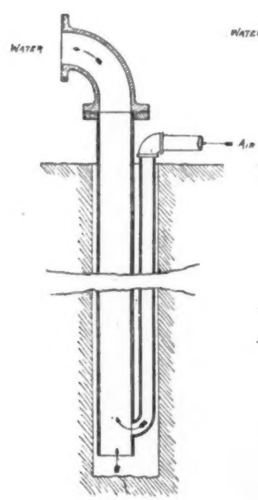


FIG. 11

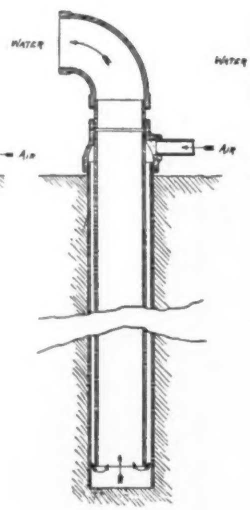


FIG. 12.

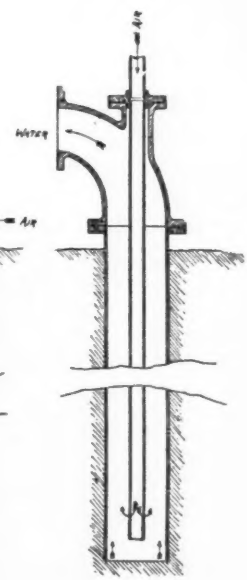


FIG. 13.

These air sections or strata of compressed air form watertight bodies, which in their ascent in the act of pumping permit no "slipping" or back-flow of water. As each air stratum progresses upwards to the spout, it expands on its way in proportion as the overlaying weight of water is diminished by its discharge, so that the air action, which may have been, say, 50 pounds per square

inch at first, will be only 1.74 pounds when it underlies a water layer of 4 feet in length at the spout, until finally this air section when it lifts up and throws out 4 feet of water, is of the same tension as the normal atmosphere; thus

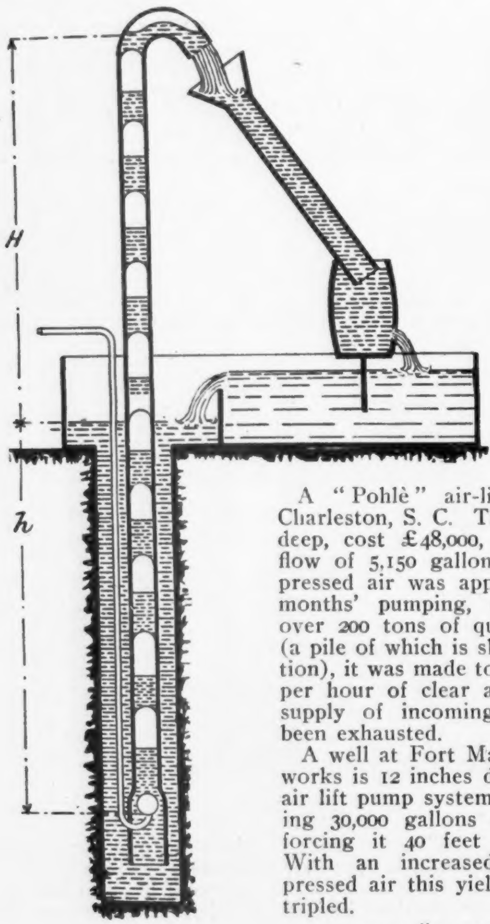


FIG. 14.

proving that this pump is a perfect expansion engine.

The original "Pohlè" air-lift pump tested by Professor Randall in company with Messrs. Browne and Behr is illustrated in Fig. 14. This pump showed the following efficiencies:

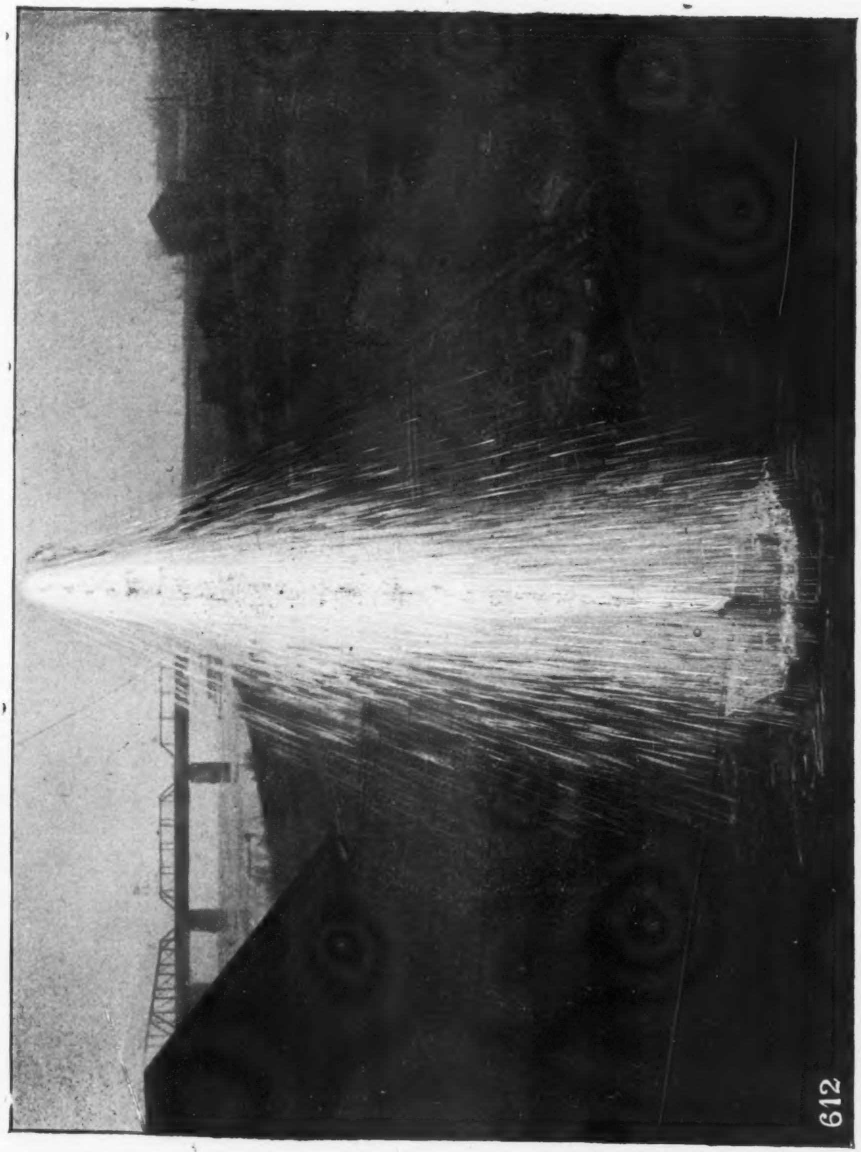
For $\frac{H}{h} = 0.5$. 50 per cent.
" " $= 1.0$. 40 "
" " $= 1.5$. 30 "
" " $= 2.0$. 25 "

A "Pohlè" air-lift pump is used at Charleston, S. C. This well is 1,950 feet deep, cost £48,000, and had a natural flow of 5,150 gallons per hour. Compressed air was applied, and after two months' pumping, during which time over 200 tons of quicksand was raised (a pile of which is shown in the illustration), it was made to yield 12,500 gallons per hour of clear and pure water, the supply of incoming quicksand having been exhausted.

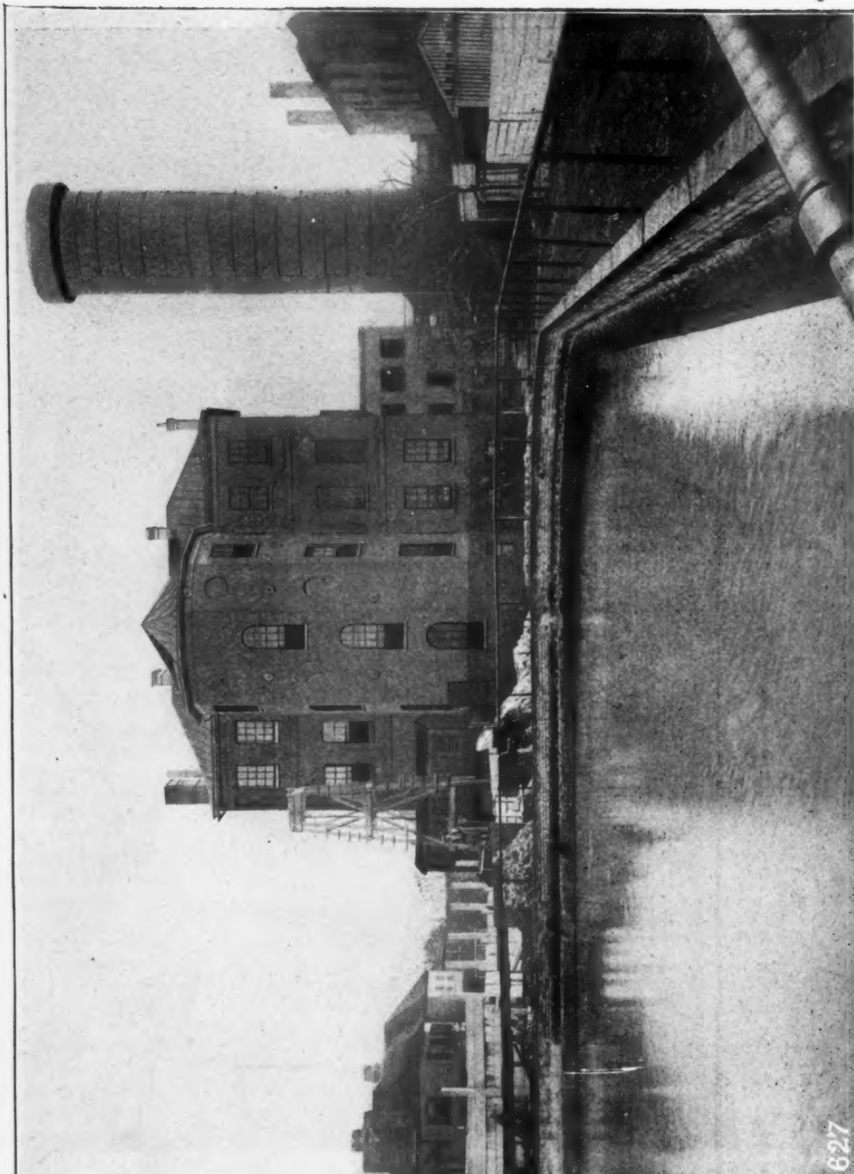
A well at Fort Madison, Iowa, waterworks is 12 inches diameter, and by the air lift pump system it is now discharging 30,000 gallons of water per hour, forcing it 40 feet above the surface. With an increased volume of compressed air this yield can be more than tripled.

THE "BACON" AIR LIFT

Is illustrated in section elevation, Fig. 17. The well head and foot piece are secured by patents. The uptake is suspended in the centre of the air pipe receiver, the lower edge of its bill-shaped attachment making a tight joint with the bell-shaped piece which is supported by the air pipe receiver.



A WELL AT FORT MADISON, IOWA, WATER WORKS.



WATER WORKS AT CHARLESTON, S. C.

In wells drilled through sand strata and having a strainer at the bottom of the well casing, the top of the uptake pipe may be closed and a sudden back pressure exerted on the well, the flow of water reversed, and the sand embedded against the strainer removed. After thoroughly cleaning a well the apparatus is adjusted to its regular duty.

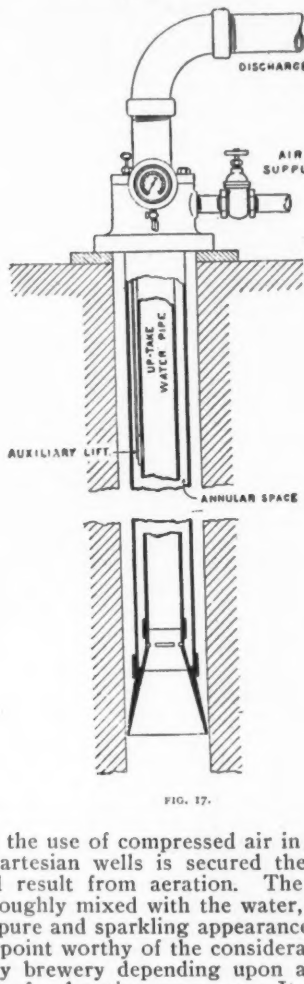


FIG. 17.

In the use of compressed air in pumping artesian wells is secured the beneficial result from aeration. The air is thoroughly mixed with the water, giving it a pure and sparkling appearance. This is a point worthy of the consideration of every brewery depending upon artesian water for brewing purposes. It is also important to factories where the employes use artesian water for drinking purposes.

Sand Blast for Castings.

Among the communications published in the October 29 issue of the *American Machinist* is one, signed "T. A. B.," which will interest readers of COMPRESSED AIR. The subject is "Sand Blasting Castings—Various Uses of Compressed Air," and reads as follows:

"Castings that are to be machined should first have the scale removed, and pickling is usually resorted to. Pickling has certain disadvantages. However much it may favor the tool, it certainly does not favor the machinist who has to breathe the dust which accompanies the cut. Pickling also takes time and sometimes has to be omitted on a 'hurry-up' job. Again, in ports and other cored work it may be essential to remove every loose particle, and pickling makes no pretense of doing this.

"There is, however, a standard method which should be used more than it is, and that is sand blasting. This is in many respects the ideal way if compressed air is available. A casting can be sand blasted 'while you wait,' and when it is done it is in perfect condition for the machinist. All scale is thoroughly removed, including that in ports and cored spaces, and there is no dust to loosen subsequently and work into cylinders, etc. I have frequently used a forming tool direct on such castings, and there is, besides, only the characteristic dirt of cast iron to endure. I do not know of a more satisfactory secondary use of compressed air in a machine shop, and, in fact, I know of one shop where a compressor was installed for this special purpose.

"This is all I started out to say, but while on the subject of compressed air I would like to mention a few more uses of it. I have used an arbor press made of an old cylinder and piston with compressed air for power. It offers an easy way of obtaining a very hot gas flame. It beats blowing through a pipe and the broken shop hand bellows as a means of removing chips. It is a satisfactory substitute for a brush in cleaning a lathe. There is at least one sprinkling system in which the pipes are filled with compressed air, the water following only when in use. The brazing fire might be mentioned as another application of compressed air and one which might be used with advantage a great deal more

than it is. Sand blasting is *the* way to clean a brazed piece.

"These are a few uses of compressed air in a machine shop, and doubtless any one, on going over the list, will note many I have left out. I think that a good many shops could consider with advantage the installing of a compressor."

A Four-Stage Air Compressor for Mining Service.

A four-stage air compressor built by the Sullivan Machinery Company for the Oliver Iron Mining Company, or the United States Steel Corporation, has recently been installed at one of the largest of the Oliver Company's mines at Norway, Michigan. The machine is 30 feet in length over all, and is rated at 210 horse power. Its capacity is between 400 and 500 cubic feet of free air per minute, which it is designed to compress regularly to a pressure of 850 pounds to the square inch. It was tested to a pressure of over 1,200 pounds to the square inch. This compressor is shown in the accompanying illustration.

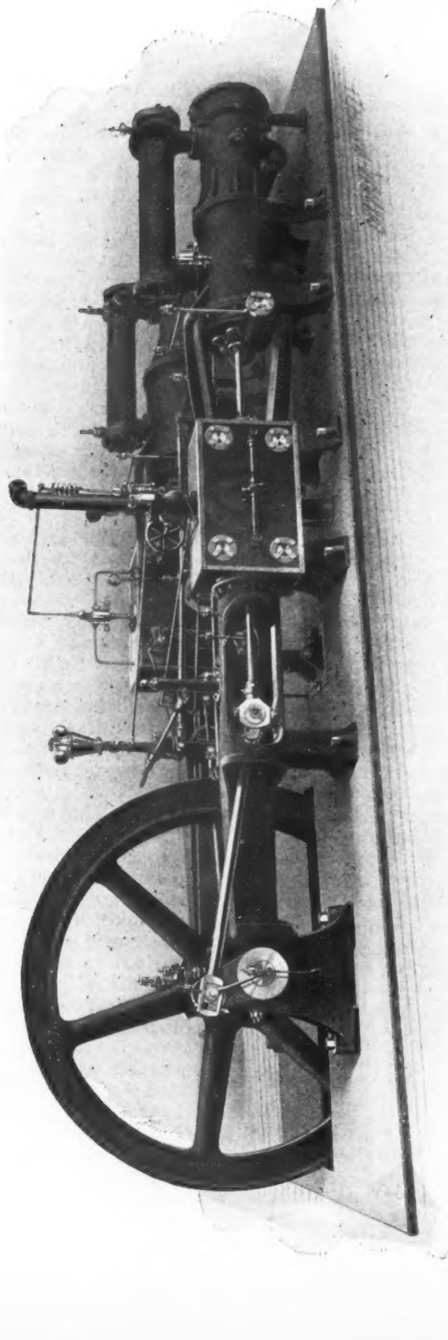
The compressor was built entirely of semi-steel, which is claimed to be much stronger and denser than ordinary cast iron. On account of the strength of the material its weight is reduced and it is therefore possible to secure a considerable saving in freight, in transporting the machine thousands of miles over a part of the country where freight rates are high. Another advantage claimed for the lightness in weight is that extra power usually required to keep in motion an unnecessarily heavy and unwieldy machine is saved. The cranks, crank shaft, connecting rods and piston rods are all made of a high grade of steel. All motion rods and pins for the valve gear are also made of steel, while the boxes and bearings for the valve gear are of phosphor bronze and are adjustable for wear. The piston rods are packed with metallic packing.

Sight feed lubricators are provided for the high and low pressure steam cylinders. The governor operates the Corliss valve gear in combination with the air pressure. The fly wheel is made sufficiently heavy to maintain a uniform speed of 10 revolutions per minute. The cross compound condensing Corliss engine built for 150 pounds boiler pressure supplies the power for operation. A reheating receiver is placed between the high and low pressure cylinders. This receiver contains a coil for reheating the steam during its passage from the high to the low pressure cylinders, and is claimed by the makers to be a feature very essential to the economy of engines of this type, especially in connection with the compressor. The cylinder lagging is made of heavy steel plate and a space of from four to five inches is allowed inside of this lagging for a magnesia covering. The lagging around the cylinder resembling a square box is filled with this non-conducting material so as to prevent loss by radiation.

This compressor is of the four-stage type, with the air cylinders so arranged that the work done in the high and low pressure steam cylinders is nearly equal. The four cylinders are single acting. In the intake and second cylinder, where the air pressure is lowest, it is compressed against the front heads. In the third and fourth cylinders, where the pressure is the greatest, the air is compressed against the back heads of the cylinders. In this way the use of stuffing boxes and piston rod packing under the heavy pressure is avoided.

The pistons in the intake and second cylinders are of the adjustable bull ring type. This kind of pistons are also used in the engine cylinders. The pistons in the third and fourth cylinders are made in the shape of a straight ram or plunger and fill the cylinder their entire length. They are also provided with a special spring packing. Special provision is made for the lubrication of these pistons and in view of the fact that they fill the cylinders their entire length the air cannot leak past them. The suction valves in the intake and second cylinder are mechanically moved. The discharge valves of the intake and second cylinders are of the poppet type and of the following design:

The valve and valve seat are located inside of a removable cage and held in place by a hand hole plate. When this hand hole plate is removed the valve cage containing the valve and seat can be removed with the hands from the recess in which they are located, without even the use of eyebolts. The pressure of the hand hole plates forms a tight



SULLIVAN FOUR-STAGE AIR COMPRESSOR.

joint between the cylinder head and the valve cage. By this method the manufacturers claim to avoid making the valve seats against part of the cylinder head, which is so annoying to keep tight when the seat becomes worn or leaky. The loose cage, valve and all, can be removed and a spare valve and cage kept on hand to be put in their place when taken out. The valve can then be ground and fitted, and be ready to take the place of the next one which becomes leaky. Where part of the cylinder head forms the valve seat, several grindings will destroy the proper shape of the seat to such an extent that when a new valve is inserted it will not always fit the seat properly. The consequences are leaky valves and valve seats.

The suction and discharge valves in the two high pressure cylinders are of the poppet type. The valves are made of nickel steel. The recess in which these cages are inserted are tapered, and the outside of the valve cage is ground to fit in these tapered recesses. The cages fit on their outside their entire length, or the thickness of the head, as it is not deemed advisable to depend on a narrow joint or shoulder for an air-tight fit under so heavy a pressure. With the smallest amount of leakage across a joint of this kind with so heavy pressure, it would soon cut away the metal, and a very small leak would impair the efficiency of the machine enormously. With these cages fitting their entire length and ground to fit like a plug cock, all danger of leakage or cutting away the metal with the high pressure is eliminated. The poppet valves in all of the cylinders are cushioned to eliminate noise or clicking.

The water jackets around the intake and the second cylinders are so designed that a body of water 3 inches in thickness circulates around the cylinder liners. The amount of water space around the third and fourth cylinders varies from 4 inches to 6 inches between the outer shell and the cylinder liner, which allows for the free and unrestricted circulation of cold water around the cylinders. The liners in the air cylinders are independent of the cylinder castings and are pressed into the outer shells with hydraulic pressure, so that in case of cutting or scoring from lack of oil, either one of these liners can be removed and new ones inserted in their place.

The flow of the air is through the mechanically moved intake valves in the front end of the forward air cylinder, located behind the low pressure steam cylinder. When compressed, it is discharged through the pipe on the side of the cylinder into the first intercooler, located below the floor line. From this intercooler it is taken into the second cylinder located on the left hand side of the machine nearest to and behind the high pressure steam cylinder. After this second compression it passes through the intercooler located on top of the second and third cylinders, and the third stage takes place after passing through this intercooler. It is then discharged through a pipe passing under the floor line from the third cylinder, and enters the intercooler located on top of the intake cylinder on the right hand side of the machine and the fourth cylinder. This intercooler is separated into two compartments, so that the air travels in the shape of a loop through the intercooler tubes and is drawn into the fourth or final cylinder where it can be compressed to a pressure as high as 1,200 pounds to the square inch. The front end of this intercooler is merely resting on the upper side of the intake cylinder. There is no connection between the intake air cylinder and this intercooler.

Copper is used exclusively in the intercoolers for circulating tubes for the cold water. The arrangement of the copper tubes in the intercooler is such that they are free to expand and contract from heat and cold without affecting the joints, so the expansion and contraction can take place without causing leakage. The speed of the machine is automatic, and varies automatically from 10 to 125 revolutions per minute. An automatic air governor acts on the automatic cut-off mechanism of the valve gear and the speed is automatically increased and decreased, according to the amount of air used.

In order to economize foundations the third and fourth cylinders may be built overhanging from the ends of the intake and second cylinders. The foundation may terminate at the back ends of the first and second air cylinders. A pedestal may then be located under the

rear ends of the third and the fourth air cylinders, and a cast-iron plate on which these pedestals rest bolted to the floor.

Questions About Compressed Air.

In the English publication, *The Science and Art of Mining,* there is a department which consists of questions for miners and engineers. A series of prizes are offered for the best replies. Among the questions in a recent number was one requiring a description of the use of compressed air as a motive power. Of interest was the reply by Mr. Geo. Wood, of West Cramlington, Northumberland. It was as follows:

"Compressed air has become such a factor of importance in mining that it is very important to understand all the many uses and advantages of it. Of all considerations in mining matters of to-day competition is so keen that decreased cost of production must be a prominent feature, and when we consider the matter we find that during the last few years vast improvements and developments have been made in compressing air so that it can be utilized for all the many purposes of mining work. In haulage compressed air cannot be excelled, as there is practically no limit to the conveyance of it, as wherever there is a road opened compressed air may be used, the power only being limited by the size of the motor.

"The earliest application of compressed air is said to have been at the Govan Colliery, near Glasgow, in 1849, where a steam engine was used to compress air to a pressure of 30 pounds per square inch, and the air was conveyed down the shaft, and to a distance of 700 yards. Since then great advancement has been made in the improvement of compressors, pipe lines, connections, motors, methods of charging, etc., until now electricity is the only power which can compete against it. Not only is compressed air invaluable as a motive power, but it is a great aid in the ventilation of mine workings, as the air given at the exhaust supplements the currents already in operation; in this way compressed air, as a motive power, can even be used when carried beyond the regular airways and range of ventilation, so reducing the risk to life and property.

"In order to compress air a steam engine is required with ordinary steam cylinders with an air cylinder. From the piston to the steam cylinder a piston rod passes through the back end, and is connected to a piston in the air cylinder. There is identity in the motion of both these, and simultaneously with the back stroke of the pistons the air cylinder is filled with air at an atmospheric pressure (15 pounds absolute) on the forward stroke of the pistons; this is compressed into about one-third, or less, space, ranging from about 45 to 60 pounds pressure per square inch. In compressing air much heat is generated, and as this cannot be retained attention is turned to the prevention of it. To accomplish this in some compressors the cylinder is surrounded with water, and sometimes water is injected into the inside of the cylinder, and the surplus water is forced out along with the air into the receiver. The use of this water is two-fold. It first cools the air, and it also fills up the space between the cylinder end and the piston, causing the whole of the air to be forced out, also the surplus water, because if any air was left in the cylinder then the air would expand to the pressure of the atmosphere, and the discharge of the air would be correspondingly reduced; the loss of work by compressed air is the taking of the heat from it.

"At Cowpen Colliery, which I visited a few days ago, a large air-compressor is in use, supplying six coal-cutting machines besides other work in haulage, with a pressure of about 80 pounds. Of course, this is not the extent of power that can be generated; in fact, a very large reserve power is expected to be utilized for this plant in a few years. The distance of the pipe line in this installation is about one mile, and the pipes are sufficiently large to allow a very large increase of energy to be conducted. This is a very important matter in the installation of air-compressors; care should be exercised to make these at the first capable of conveying sufficient air to do all the work, so that any additional cost will only come in the shape of increased compressing power and additional motors.

"Experiments have proved that if the air be re-heated before entering the engine considerable economy is obtained. This may be done by two methods, either by passing the air

through hot pipes heated by a furnace fire, or by passing the compressed air through water in a boiler at a temperature depending on the pressure in the boiler. The former is called the dry method and the latter the wet or moist method of heating. Generally speaking, by this re-heating process an additional horse-power can be obtained with an expenditure of one pound of coal. As the loss of power due to the absorption of energy in the generation of heat is one of the chief defects in air compressing it can readily be seen that re-heating may be of immense importance in overcoming it.

"Allow me to itemize generally the advantages of using air-compressors:

"(1) The air may be stored to any extent or carried any distance without loss of pressure, except that due to friction and leakages.

"(2) Hand tools can be used when steam would so heat them that it would be impossible to handle them.

"(3) It can be used at any pressure, is easily generated, and its expansive qualities make it a very acceptable force.

"(4) The exhaust, instead of being detrimental, as in the case of steam, is supplementary to ventilation, and acts with beneficial effect on the workmen with its cooling and refreshing power.

"The fact that we cannot take up a paper to-day without seeing some reference to this all-important subject is sufficient evidence of the progress that compressed air is making in the commercial world generally, but to deal exhaustively with such a subject would need a whole book instead of a few lines, so that one can only state a few facts, trusting that amongst them something new and suggestive may be found."

In the same issue is a question concerning wet and dry air compressors, and which class is the more preferable. The following reply by Mr. Thomas White, of Larkhall, Scotland, is published:

"In dry air compressors no water is admitted into the cylinder, but instead the cylinder is surrounded, or nearly surrounded, by what is termed a water jacket. As a rule where the water jacket is adopted the compressor is laid over a trough containing clear, cold water. The object of the cylinder being surrounded by water is that the cooling action of the water tends to keep down the temperature of the air during the process of compression.

"The action of the dry air compressor may be briefly stated thus: The air compressor is a cylinder with proper inlet and delivery valves, and a piston for compressing the air. On the outstroke of the piston air passes through the inlet valves into the cylinder, and on the commencement of the return stroke the inlet valves close, and the air in the cylinder is compressed until it lifts the delivery valves, and is forced into the receiver.

"In wet air compressors water is introduced directly into the cylinder during the compression of the air. By the compression of the air heat is generated, therefore the object of using water in the cylinder is to absorb the heat resulting from the compression of the air. Sometimes the water may exist in volume, both before and behind the piston, washing to and fro in the compression chambers at each stroke of the piston. When this goes on for some time the water itself becomes hot from the absorption of heat from the air, and loses its power of cooling.

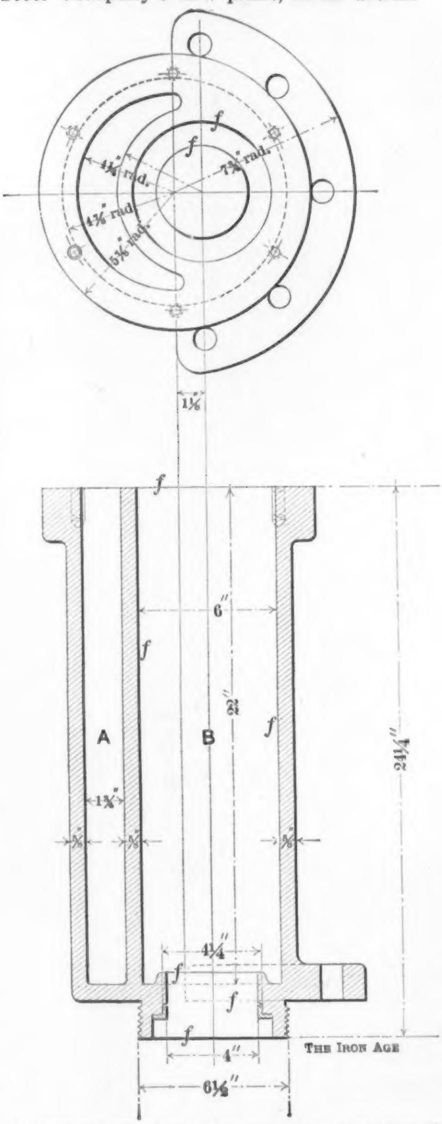
"Another and perhaps more efficient method of cooling the air is sometimes adopted by injecting a fine spray of water into the cylinder during the compression stroke.

"The wet air compressor sometimes gives very good results, but in actual practice the dry air compressor is generally preferred. An objection to the wet compressor is that the air is saturated with moisture, which has a tendency to form into ice in the exhaust parts of the motor. Again the wear and tear of the cylinder and piston is excessive, for water is a very bad lubricant itself, and oil or grease introduced for lubricating floats on the water and fails to reach the working parts.

"For a given output of the air the wet compressor must necessarily be larger than a dry one, because on account of the inertia of the water the speed at which these compressors should travel should not exceed 150 feet per minute at the surface of the water."

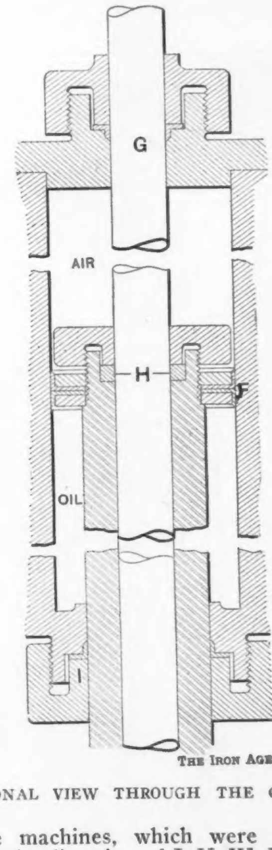
Pneumatic Reamers.

In a description of the Pennsylvania Steel Company's new plant, in an article



PLAN AND SECTIONAL VIEW OF THE CYLINDER.

entitled "A Model Bridge and Construction Shop," the *Iron Age*, in a recent issue, describes and illustrates pneumatic reamers which are being used there to ream the rivet holes in order to insure an accurate and true bearing for the rivets. To economically perform this operation it is necessary to have an easy movable machine, as it is more advisable to shift the tool than the work. To have only one tool at work at a time would also prove expensive and cause delay.



SECTIONAL VIEW THROUGH THE CYLINDER.

These machines, which were designed under the direction of J. V. W. Reynders and built by the Baush Machine Tool Company, conform with all the required specifications.

The spindle is fitted and turned by a combined oil and air pressure, which, as expressed by the *Iron Age*, works in a closed circle. This operation is illustrated in the accompanying sectional

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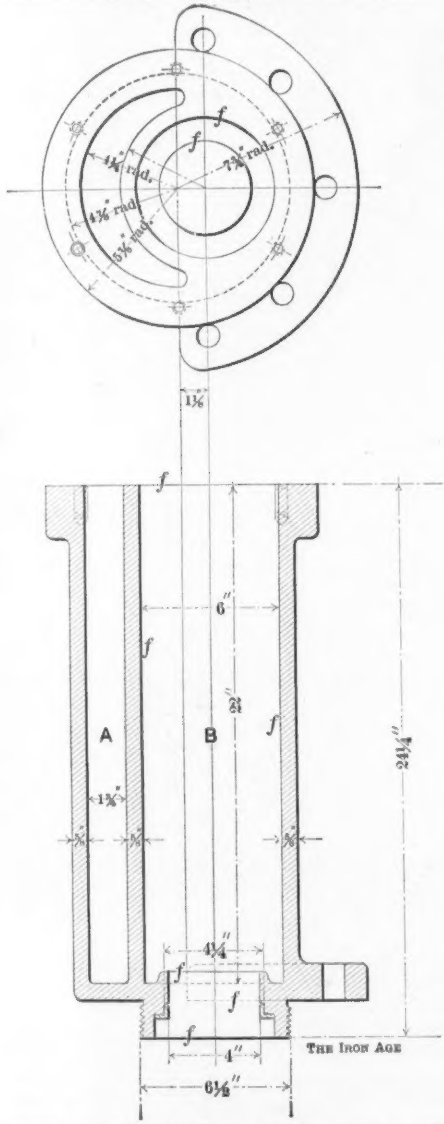

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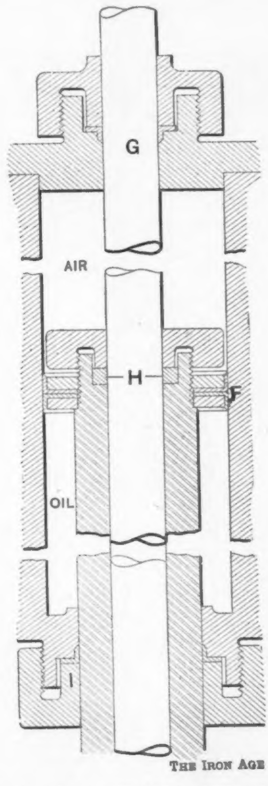

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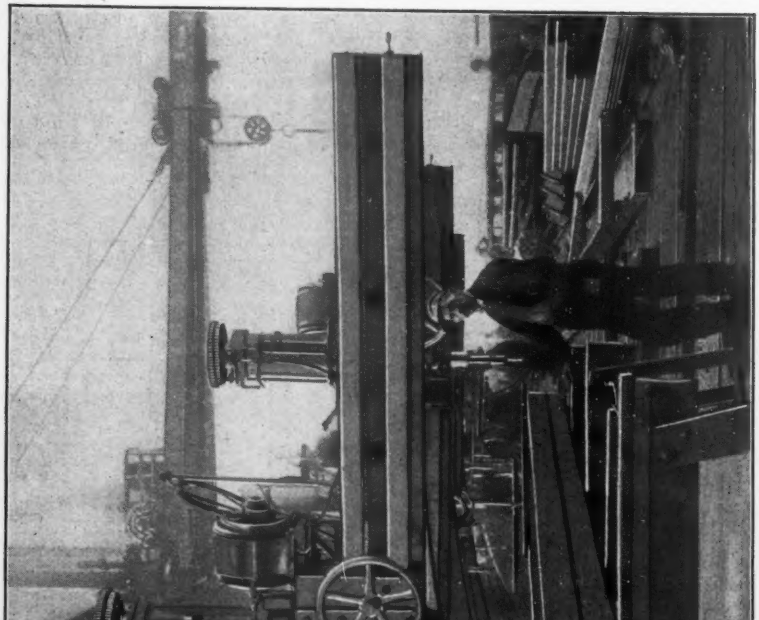
These machines, which were designed under the direction of J. V. W. Reynders and built by the Baush Machine Tool Company, conform with all the required specifications.

The spindle is fitted and turned by a combined oil and air pressure, which, as expressed by the *Iron Age,* works in a closed circle. This operation is illustrated in the accompanying sectional

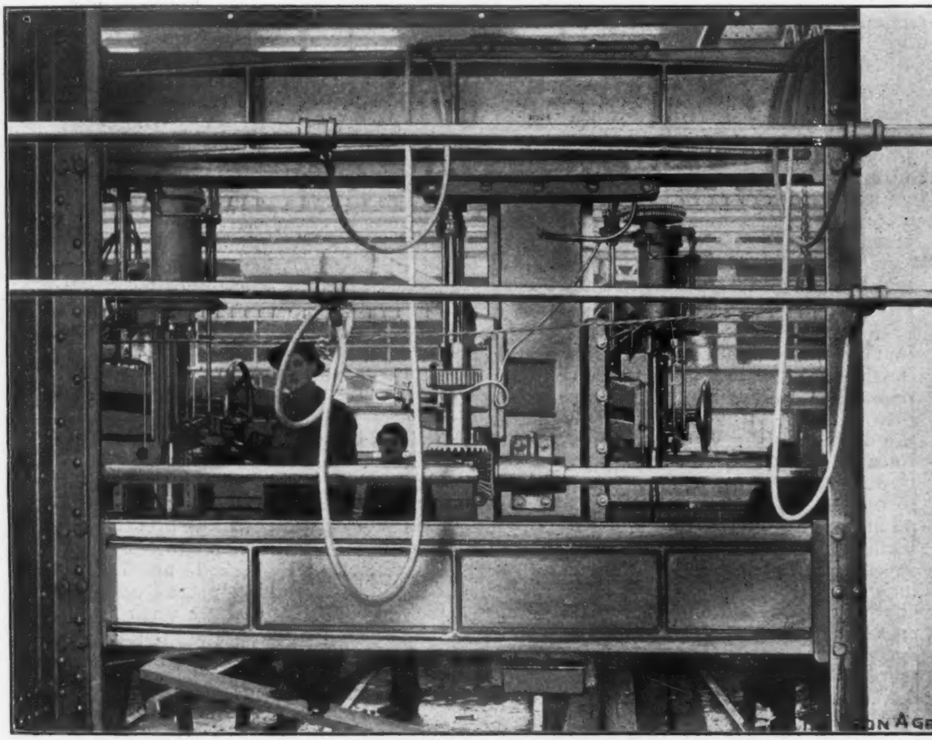


SIDE VIEW OF THE REAMERS.

illustrations which are published through the courtesy of the *Iron Age*.

The spindle terminates at its upper end in a piston which works in the cylinder B. Air is admitted on top of the piston at a suitable pressure depending on the character of the work to be done whether solid drilling or reaming, the usual pressure being about 60 pounds per square inch. Underneath the cylinders and connecting with the auxiliary chamber A by means of a regulating valve is an oil reservoir which not only regulates the feed of the drill, but also acts as a dash pot to prevent too rapid movement of the spindle after the drill has passed through the work.

The various movements are accomplished by a suitable valve arrangement in convenient reach of the operator. This provides an elastic though constant pressure on the drill resulting in the true feed which accommodates itself instantly to any variation in the resistance presented to the cutting tool due to the irregularity of punched holes or material. The machines are supported upon two horizontal beds or rails placed in the same vertical plane. Each machine can be moved in any desired position on these rails. The entire group is shifted independently and the arm raised or lowered by power.



REAR VIEW OF THE REAMERS.

The Use of Compressed Air for Operating the Contractor's Plant at the Wachusett Dam.

Some of the advantages arising from the use of compressed air on contract work were outlined editorially in our issue of June 4, 1903, and now we have the pleasure of citing an object lesson that is particularly impressive, not only by virtue of the magnitude of the work involved, but also by virtue of the excellent results that have followed the use of compressed air on so large a scale.

To generate 1,000 horse-power at a central plant, and to convey the power to some 80 different engines, is in itself impressive, but to have kept such a plant in continuous operation for a period of 32 months is a record that, so far as we know, has never been equaled on contract work. In view of this fact some details of the plant and its operation will be of especial interest to contractors having similar work to do.

In the first place, it should be stated that the power station is located between the dam and the quarry, the distance to the dam being nearly 1¼ miles, and to the quarry half a mile. Power for operating the drills, derricks, etc., is supplied by two Rand-Corliss air compressors, of 500 horse-power each. The engines are designed to operate under a steam pressure of 135 pounds, with steam cylinders 18 and 34 inches diameter for the high and low pressure, respectively and have a 42-inch stroke. The air cylinders of each compressor are 21 and 34 inches diameter for the high and low pressure, respectively. At the normal speed of 75 revolutions per minute, each compressor delivers 3,310 cubic feet per minute of free air raised to 90 pounds per square inch. The engines are so designed that either high or low pressure cylinder may be run independently. Water for the boilers is secured through a 3-inch pipe from a pond about a mile away, and condensing water is drawn from a pond alongside the power-house. The compressed air is discharged through a 10-inch pipe into a horizontal air receiver 6 feet diameter by 20 feet long, and the air is delivered to the works at the dam through an 8-inch pipe, 6,500 feet long.

At the present time the following engines and machines are being run with the air from this plant:

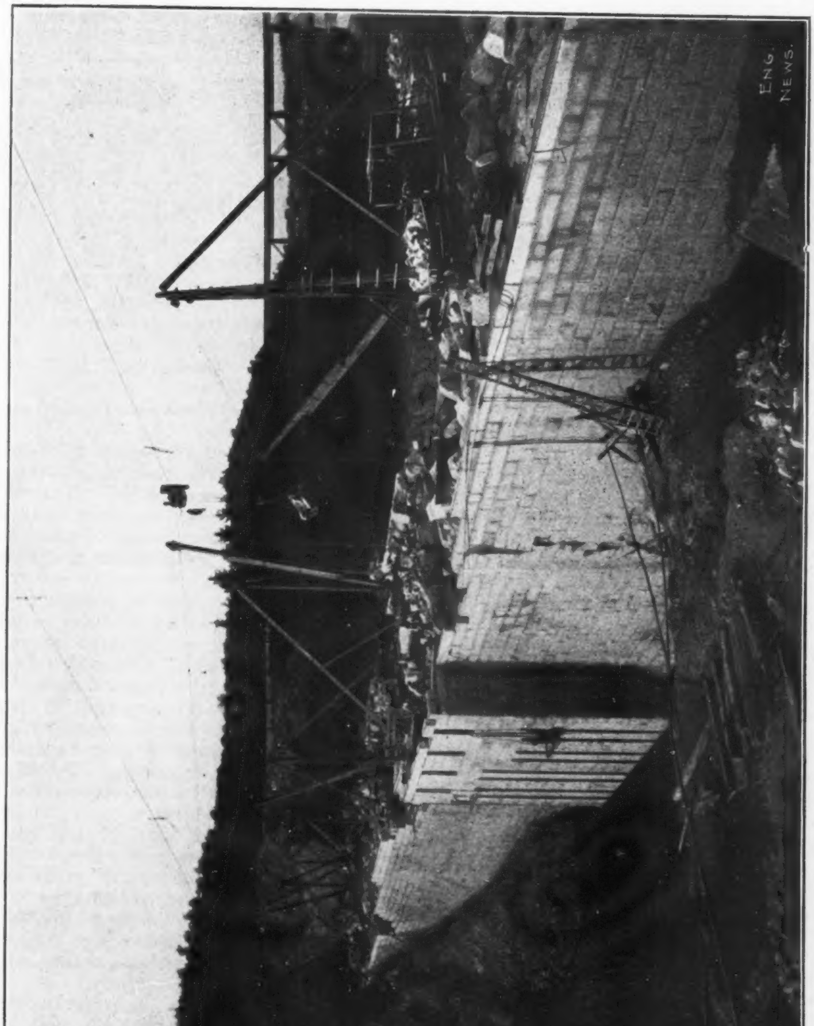
31 hoisting engines, about 16 horse-power each.
2 cableway engines, about 50 horse-power each.
16 No. 3 Rand drills.
3 pumps, 3 to 4 inch discharge.
1 engine on revolving screen, 10 horse-power.
1 engine in machine shop, 10 horse-power.
1 engine on mortar mixer, 10 horse-power.
1 pneumatic riveter.
1 trip hammer.
3 stone dressing machines.
10 blacksmiths' forges.
10 pneumatic plug drills.
—
80 total.

While as before stated, these machines are for the most part concentrated at two points, the dam and the quarry, still it is noteworthy that one derrick is being operated by air fully three miles away from the compressors, and the air pressure at this derrick is practically the same as at the compressors.

These 80 machines work the compressors to about two-thirds their capacity, but a few months ago when some 40 Rand drills were in operation the compressors were worked almost up to their full capacity. At no time, however, have there been many more independent machines in operation than at present.

In the quarry the rock is loaded into skips which are picked up by air-operated derricks and placed upon flat cars, where men with hose wash all dirt off the stones. The cars are hauled over a standard gauge track to the dam, where the cableway lifts the loaded skips and delivers them directly to the derricks on the dam, so that there is no manual rehandling of the stone from the time it is loaded into skips until it reaches its place on the dam.

The stone, which is a granite, breaks out irregularly and in massive blocks. Holes are often 24 feet deep, and are 3 inches diameter at top and 1¾ inches at bottom. Including delays involved in setting up the drills in difficult positions, two 24-foot holes are regarded as a fair day's work for a drill in this granite. Only a small amount of the face stone for the dam is taken from the quarry.



UP-STREAM FACE OF THE WACHUSETT DAM, SHOWING PROGRESS OF CONSTRUCTION.

For splitting or squaring up large, irregular blocks the contractors have found pneumatic plug drills especially effective. The Kotten pneumatic plug drill does not have an automatic rotating device, but the bit is turned with a wrench in the right hand of the operator. By virtue of turning the bit thus by hand, the drill mechanism is very simple and the drill is certainly effective, as 6 holes, ⅝-diameter by 3 inches deep, are readily drilled in 9 minutes.

A number of large stone surfacing machines are also operated with compressed air, but we reserve a description of their work for another issue.

Not only are all the forges of the blacksmith shop run with compressed air, but a large trip hammer is operated with the same power.

We have indicated briefly the many uses to which compressed air may be put on contract work of this character, but it should not be forgotten that not the least of its advantages over steam is the fact that licensed engineers are not required to operate an engine driven with compressed air. The contractors lay particular stress upon the ability to quickly train a man to run an engine where air is used, and the consequent freedom from the dictates of unions. Moreover, to cart the coal to a large number of separate engines would in itself be an item of great cost in the aggregate on work so widely scattered as this. Then, too, to fire up in the morning and to draw the fires at night involves not only a loss of fuel, but longer hours for the engineman, all of which is done away with where compressed air is used.

The economy in fuel that results from generating power by a few large units at a central plant is a fact universally recognized by engineers, but not so often recognized by contractors, or, if recognized, is not often used to advantage as in the plant above described. One of the reasons that in the past has led contractors to hesitate to install large central power plants has been the fear of breakdowns that would tie up the whole work. But in so reasoning the perfection of modern machinery is lost sight of. There is a good bit of wisdom in "Pudden' Head Wilson's" philosophy, where he says:

"Some say, 'Don't put all your eggs into one basket,' but I would say, 'Put all your eggs into one basket—and watch that basket.'"

This maxim holds as true of investments in machinery as of investments in stock.—*Engineering News.*

Modern Slate Quarrying.*

At all the quarries in the Festiniog district the rock is won by true mining underground, on what is known as the descending method. This system consists of a main incline tunnel running from the top of the slate bed it is intended to work down to the bottom. From this inclined tunnel, long cross tunnels are driven off left and right, which are termed floors. Each of these floors is again apportioned off with "pillars" and "chambers," the average depth of each chamber being about 50 feet, although in some cases they run as high as 80 or 90 feet.

The first operation, when a chamber has been apportioned off, is one termed "unroofing and widening." This consists of removing the rock for a thickness of about 3 feet to 4 feet over the whole surface area of the chamber, through and up to the floor above. As this work is done by miners and with high explosives it is entirely unproductive, and is, in fact, a very expensive item in underground quarrying, as, not only does it result in the waste of some hundreds of tons of good rock, through its being broken too small for slatemaking purposes, but this waste has to be cleared and tipped at a cost varying from 6d. (in a few exceptional cases) up to 1s. or more, per ton.

After the miner has completed his "unroofing" operations, the chamber is ready for the "rockman." The work of this individual is to mine the rock and send it, in the form of large blocks, to the surface, where it is taken to the mills, sawn, and dressed into roofing slates ready for the market.

In "getting" the rock the waste is very high, and owing to the depth the rock very often has to fall to the floor when blasted. For every 100 tons of rock sent to the surface for dressing into slates, about 100 ton weight is also sent

* Extracts from an article by Mr. A. Dawes in *Page's Magazine* (England) describing the Rhiwbach Slate Quarry, Blaenau, Festiniog.

up in the form of rubbish, which has to be cleared and tipped; in fact, of the total rock removed in the quarry a proportion of one ton of slates to 14 tons of rock is considered very fair, although in many cases the amount of waste is much higher even than this.

At this quarry it was decided to develop a part of the estate which had not previously been touched, and with this object, operations were commenced in a bed of slate about 300 feet to 350 feet thick, covered with a topping of peat and clay about 30 feet thick. This bed had been proved by borings some forty years ago, but no attempt had been made to work it.

The first operations were commenced in 1898, and consisted of the driving of the usual inclined tunnel, 500 yards long. In order to drain the workings and permanently dispense with pumping operations, a tunnel 842 yards long was continued from the foot of the incline to the foot of the mountain.

With a view to pressing on with the work as speedily as possible, driving was arranged for at both ends, but operations were commenced at the inclined tunnel end with an open cutting through the surface clay for a distance of about 50 yards, and then the tunnelling was commenced, still in the clay.

As the tunnel was advanced it was arched with waste ends from the dressing sheds, and for a time everything proceeded in a satisfactory manner. Owing, however, to the soft and shifting nature of the ground the arching very shortly collapsed.

Timbering was next tried, but without much success, as the timbers were constantly shifting. To overcome this difficulty the tunnel was lined for a short distance with old boiler shells 7 feet 6 inches diameter, which have answered remarkably well, for during the past four years no further difficulty has been experienced with them.

As the work proceeded, the ground became a little firmer, and timbering became possible, until the site of an old well was driven into which caused a deal of trouble and delay. This, however, was overcome in the end, and the work proceeded steadily until the solid rock was reached, when timbering became unnecessary.

Water had all along caused a deal of trouble, and to clear it pulsometers were used, which were hung in chains and provided with steam from a small vertical boiler on the surface. These worked very well, and efficiently handled the dirty water and mud.

The level had been commenced at the other end, but as this was all through solid rock, no difficulty was experienced, the water all finding its way out without mechanical assistance. As hand work did not proceed at a very rapid rate an air-compressor was erected at the quarry, and the work was thenceforward carried on with the aid of rock drills; air at 70 lbs. pressure being conveyed over the mountain to the forebreast in a line of 2-inch tubes, nearly a mile and a half in length. The rate of driving in the level was five to six yards per week.

At the inclined tunnel end serious difficulty was caused by the water, and as the forebreast had now got far from the surface a double ram pump, by Pearn, of Manchester, was put in and driven with the compressed air. The exhaust air from the cylinders was turned on to the forebreast, and very speedily cleared the place of smoke after firing. The pump was constantly moved forward as the work advanced.

The levels and gradients were carefully watched, and when the level was completed, driving up was commenced to meet the men who were going down.

When both ends met there was not the slightest difference in level between them.

The costs for driving were as follows:

FOR THE LEVEL.

	Cost per yd.		
Wages and explosives........	£2	14	7
Enginemen	0	6	0
Coal, oil and engine stores....	0	10	11
Surveying	0	1	2
Sundries	0	0	7
Giving a total cost per yard of	£3	13	3

FOR THE INCLINED TUNNEL.

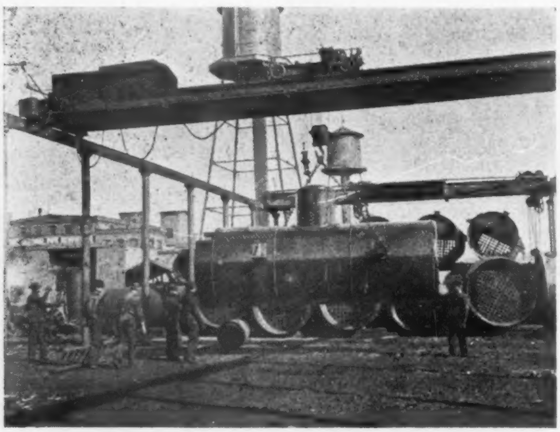
Wages and explosives........	£4	1	6
Enginemen, coal, oil, engine stores, surveying and sundries	0	18	8
Or a total cost per yard of..	£5	0	2

The total amount of slate rock opened out by this inclined tunnel and level is 40,000,000 tons. Of this, 16,000,000 tons

are capable of producing slates of the finest quality, while 12,000,000 tons will give slates of a fair quality, the remaining 12,000,000 tons being of an inferior nature and not worth working.

A Pneumatic Traveling Crane.

The September issue of *Motive Power* contained a description of the works of the Biglow Company, New Haven, Conn. Among the illustrations was the accompanying one, which shows a pneumatic traveling crane handling a boiler. Compressed air proves a great power at that shop in handling the large boilers which are turned out there at the rate of seven a day.



PNEUMATIC TRAVELING CRANE.

A New Type of Air Compressor.*

A novel type of air compressor has been made for some time past by an English company, Messrs. Reavell & Co., Ltd., of Ipswich, England. They are now making the same type in the compound or two-stage type, a recent machine for 100 pounds pressure, being intended for one of the underground tube railways that are becoming so common. The idea of Mr. Reavell was to make a machine suitable for direct driving by an electric motor at a moderate speed, to occupy a small space and be of small weight, the latter point being secured to some extent by dispensing with the fly-wheel, as will be shown hereafter.

The general arrangement of the machine, Fig. 1, is duplex, there being two compressors, one on each end of the motor shaft. There are only two bearings, and these are of great length and carried in the uprights of the framing by means of sleeves which can be removed and replaced so that the bearing can be removed as required. On the outer ends of the shafts are placed single cranks, on each of which four connecting-rods take their bearing. The compressor frame is a hollow ring casting not unlike the field frames of an electric generator, Fig, 2. At four equal angles the frame is bored out to take the compressor cylinders. These are forced into the bored-out frame through openings on the outer circumference, which are closed by circular bolted flanges. Each cylinder is double, and consists of a first-stage cylinder 10 inches in diameter, and a tandem 5-inch second-stage cylinder. The two pistons are also cast in one piece, the connecting-rod crosshead end being at-

*By W. H. Booth, in *Mines and Minerals*. Illustrations supplied through the courtesy of *Mines and Minerals*.

tached to the first-stage piston, which forms of itself the crosshead like the piston of a gas engine. The stroke is only $4\frac{11}{16}$ inches, and the speed is 240 revolutions per minute, at which speed the compressors with their eight double cylinders will compress 300 cubic feet of free air per minute.

The large piston draws in its air through the crosshead bearing, to which the connecting-rod head forms a valve. On the complete out-stroke, the piston uncovers a ring of ports round the cylinder, and this insures that full atmospheric pressure is admitted to the cylinder at each stroke. From the first stage the air is forced through the delivery valves into a chamber which is connected by waved copper pipes to all the other first-stage delivery chambers; and, though all the cylinders are thus connected, the actual course of the air is from each cylinder across or around to the opposite second-stage cylinder. The second-stage cylinders compress the air, now cooled in the casing or tank which surrounds the cylinders and is filled by water, and discharge it into a passage which runs around the casing and is provided with three outlet ports, any one or all of which can be used at will to take off the compressed air. All the valves, both of the large and small cylinders, are alike and interchangeable, and consist of light steel cup valves in gunmetal seats. Valve capacity is given by the number of valves employed, not by change of size, and the number of spaces is reduced and chances of error are eliminated.

The accompanying diagram, Fig. 3, is a combined torque diagram of the two compressors, the diagram of each being in dotted lines. If this torque diagram be further corrected for the flywheel action of the motor armature it will become nearly circular, showing that no special flywheel is needed. This even-turning movement is due to the crank angle of 45 degrees so that there are eight deliveries of air per revolution, and, consequently, no fluctuation in the pressure of supply.

When supplying air to tools in an engineering workshop such as pneumatic hammers, tappers, air lifts, etc., it is nec-

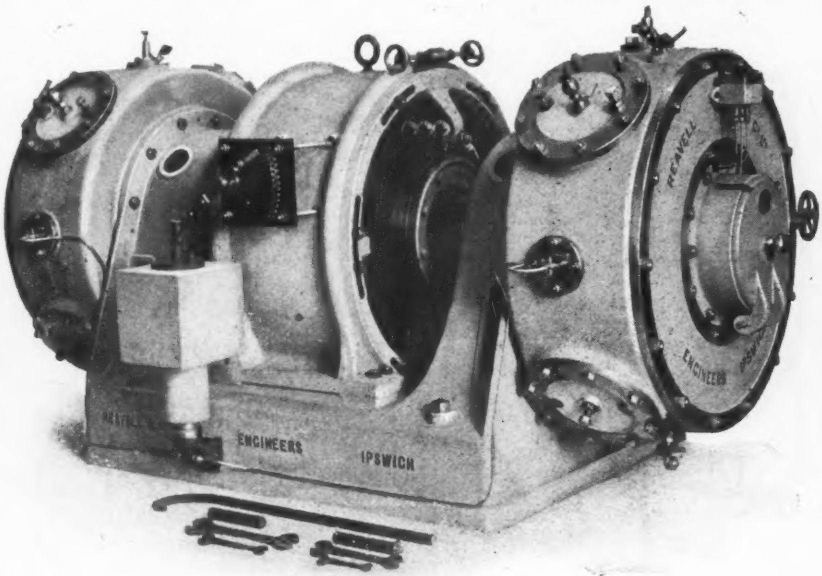


FIG. I.

essary to maintain a fairly even pressure. By means of the field rheostat the speed of the motor can be regulated in the ratio of 2 : 1, and this is arranged to be done automatically. An air plunger, supplied with compressed air, is balanced by a heavy weight in a lever, one end of which is connected to the field rheostat. This device can be arranged so that for any desired range of pressure, of say 5 pounds, the motor speed will be regulated between its maximum and minimum. The reservoir pressure cannot, therefore, vary more than 5 pounds from normal. If, however, at any time even half speed of the motor delivers too much air, there can be also employed a special further device which cuts off the air supply when the pressure reaches a maximum and prevents the compressor from working to waste through the safety valve. This saves power from being needlessly wasted. If, as in mining work, the air is wanted in considerable volume at intervals only, it is better that the motor should run intermittently at full speed or be kept standing entirely.

Mr. Reavell's idea of air compression is that it is better to carry an electric cable into a mine and there drive an air compressor near to the point of use than it is to compress the air at the bank and carry the air down the mine in pipes.

The first stage of compression takes place between the two pistons. As their ratio is 4 to 1, the ratio of compression must be 3 to 1 in this stage, the second stage, of course, being what the compressor is allowed to do. The limit to which a compressor can work is determined by the ratio of its clearance capacity to its cylinder volume. If a piston has a stroke of 5 inches and a clearance of one-quarter or one-twentieth, then the maximum compression will be to increase the pressure supplied to that cylinder twentyfold. But during the latter part of the range the compression would begin to be very inefficient. Hence the use in some compressors of a jet of water to keep the clearance spaces full and render the compressor as efficient as possible.

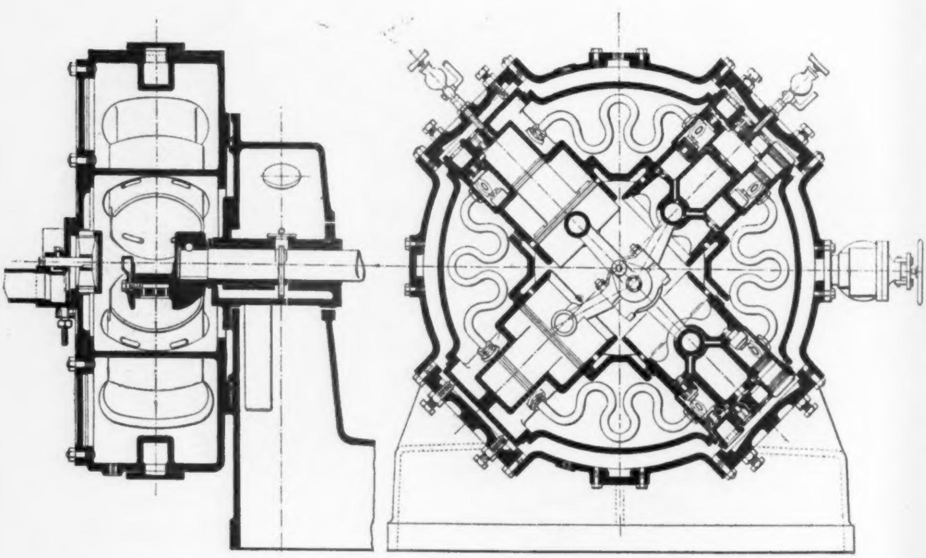
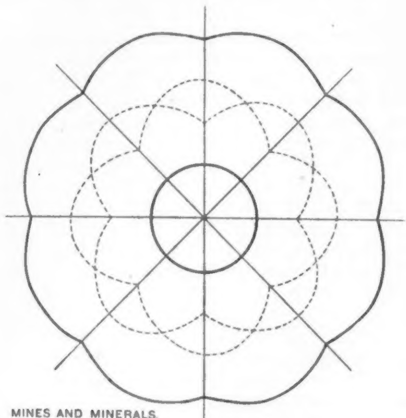


FIG. 2.

The advantage of two-stage compression is that the air heated by the first stage may be thoroughly cooled off before being subjected to the second stage. Air is so perfect a gas that nearly all the

work done in compression will appear as heat and the absorption of work is thereby much increased. By dividing the whole compression into two stages with intermediate cooling, a large part of the extra work is saved. Moreover, in



MINES AND MINERALS.

FIG. 3.

single-stage compression the pressure runs up very suddenly at the end of the stroke and this is avoided in a two-stage machine, which has the further advantage that the maximum air pressure is against a smaller piston and the risk of loss past the rings is less. The form of piston ring

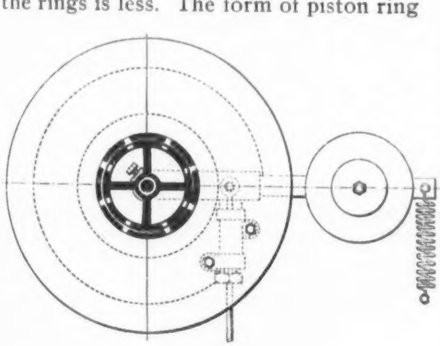


FIG. 4.

employed is one that is turned an exact fit in the cylinder and expanded by two inner rings each half as wide. The joints of the three rings are 120 degrees apart.

Similarly arranged compressors are employed to compress air to 1 ton per square inch for use in torpedoes, which, however, cannot be looked upon as comparing favorably with the use of air in workshops and in mining.

Being practically a perfect gas at all ordinary temperatures, air follows Boyle's law, which states that at any given temperature, the product of the volume and pressure of a gas is a constant quantity; or PV = a constant, or $Pv = p\,V$, where P and v are the pressure and volume at one time and p and V are the pressure and volume at any other time.

This is the isothermal equation and is the equation of the hyperbolic curve.

The adiabatic curve of a perfect gas is $\frac{P}{p} = \left(\frac{V}{v}\right)^{1.408}$. Assuming one volume to be unity, or say $v = 1$, there is obtained $\frac{P}{p} = \frac{V^{1.408}}{1}$, or $P = p\ V^{1.408}$.

Thus, air at 15 pounds is compressed to 90 pounds. Then $\frac{P}{p} = 6$.

What will be the relative volumes before and after compression? Here the final volume is assumed as $1 = V$.

Now $\frac{V^{1.408}}{1} = \frac{P}{p} = 6$. The logarithm of $6 = 0.77815$. This divided by $1.408 = 0.55261$, which is the logarithm of $3.57 = V$.

Thus in place of having obtained a six-fold pressure by means of six compressions, we have secured it by only 3.57. the difference being due to the heat generated by the work of compression. Thus, in compressing air, the subsequent cooling of the hot air deprives it of the pressure and it is reduced when cool to only 3.57×15, or less than 54 pounds in place of 90 pounds, and the difference must be made up by working the compressor for a longer time. Compression in a water-cooled cylinder helps to correct the evil partially, but owing to the difficulty of cooling rapidly, compressors cannot be run fast , but must allow time for cooling to take place during the stroke. Hence the gain by two-stage work.

Where air is compressed in an outside cold atmosphere and carried into a hot, deep mine, the heat of the earth is made useful in getting out of the air more than was put into it, in a sense. But this is

not necessarily an argument in favor of compressing at bank, because mines which are hot may also be deep and the compressor works between wider limits of pressure. Thus in a mine 6,000 feet deep the air pressure is greater at the bottom by about 461 pounds per square foot; or say 3.2 pounds per square inch, calculated on the air measuring 13 cubic feet per pound at sea level.

If all the 6,000 feet were below sea level, the difference would exceed this figure, and it would be less where the mine depth is all above sea level. For high elevations the first or large cylinder of an air compressor must be increased to allow for the rarified atmosphere. For cases where the air is used at or near its horizon of compression, this point is of less importance, because the back pressure is so much less. But in any case it requires more cylinder capacity to get hold of an equal weight of air, and it depends on the mass of the air which works, as to the amount of work that can be done by it.

In Fig. 2 is given a cross and longitudinal section of a quadruplex, two-stage machine, showing the single crank with its oiling device, the compound cylinders, cooling pipes and water spaces, with the arrangement of bonnets and air-delivery openings. One standard and its long interchangeable bearing sleeve is also shown.

I recently tested a double quadruplex machine for efficient action. First, I tested when pumping air into a reservoir at atmospheric pressure until it attained a pressure of 82 pounds, and a volumetric efficiency of 94 per cent. was obtained. Next the reservoir, into which the air was delivered, was first pumped up to 82 pounds; it was kept at this, and air only allowed to escape through a throttle valve into the measuring vessel until this also attained 82 pounds. The volumetric efficiency of the second test was 90 per cent., showing that the clearance spaces of the machine were small. Of course, the second method of test is the only proper method, resembling the conditions of practice, the closeness of the efficiency by the two different systems of testing demonstrating this.

The use of water to fill the clearance spaces of a compressor is often found to give rise to trouble in the shape of ice in the exhaust of machines using the air. It is better, when possible, to use a dry compressor, and to do this the clearances must be small, especially when compound compression is used; in the first stage or larger cylinder, the piston must come close up to its cylinder head and the eduction valves must be close to the cylinder also and leave but little waste space.

For working with alternating current, geared motors are required, owing to the speed, and Messrs. Reavell have recently had before them a proposition for driving compressors from single-phase current at 83 periodicity. They very successfully met this problem by means of a centrifugal clutch, which allowed the motor to get quickly away and prevented the initial rush of current that is so annoying, not so much from the waste it causes as from the fluctuation of all the lamps near by. This fluctuation of lamps is overcome by a centrifugal clutch, which will allow a two-thirds full speed to be attained before it begins seriously to take up its work. As the centrifugal force varies as the square of the speed there is a margin of the ratio of $(\frac{2}{3})^2$ to $(\frac{3}{3})^2$, or say 4 to 9 as between the beginning and end of the clutch action. The outer shell of the clutch, on which the preliminary rubbing of the friction blocks is expended, is made fairly massive so as to absorb the frictionally generated heat with small rise of temperature. The compactness of these air compressors and their easy driving, point them out as particularly suited to mining work.

In Fig. 4 is shown the automatic air valve which shuts off admission when the pressure in the delivery pipes rises to a predetermined limit, thus making it possible for a compressor to continue to run without pumping to waste. This is exactly the converse of the setting of the valves of a steam engine so as to entirely prevent steam admission when a given limit of speed is attained, thereby enabling a lightly loaded engine to produce in itself a vacuum right up to the stop valve.

Air Signals for the Bengal-Nagpur Railway.

The enormous increase of goods traffic on the Bengal section of the Bengal-Nagpur Railway during the past twelve months, more especially since the opening of the Jherria coal fields to the com-

pany, has directed the attention of the management to the necessity of improving the ordinary system of manual signaling in their large yards at Kharagpur, Adra and Santragachi. The number of trains passing through the first named junction daily has been quadrupled since the increase in the coal traffic, and W. T. C. Beckett, the acting agent, anxious to maintain his company's reputation for up-to-dateness, as also to increase the efficiency of the working, addressed the home board in the fall of last year on the subject of introducing some power system of signaling, which had already been tried and proved successful on some great lines in England. The board admitted the justice of the agent's representation, and referred the matter to Sir John Wolfe Barry, the consulting engineer to the company in London, for early report.

The problem did not admit of easy and offhand solution. The difference in the conditions, climatic and industrial, of India and England, had to be taken into consideration, and more than six months were passed in careful consideration and investigation before Sir John Wolfe Barry made a final recommendation. While admitting the great advantage of power over manual systems, the consulting engineer did not think that the installation of the former on the Bengal-Nagpur Railway was at present an absolute necessity; yet he was willing to concede that it might become so in the course of a few years, when the number and speed of fast passenger trains would be greatly increased. It also appealed to him that were a manual system erected in the first instance, the subsequent adoption of a power system hereafter would necessitate the scrapping of nearly the whole of the manual system machinery long before it was worn out. On these considerations, he commended the idea of a power system, pointing out that the greater initial cost would be compensated by efficiency and reduction of staff. In this view the board have concurred, and have authorized the agent in Calcutta to apply to the Government of India for sanction to equip the yards at Santragachi, Kharagpur and Adra with power systems of signaling.

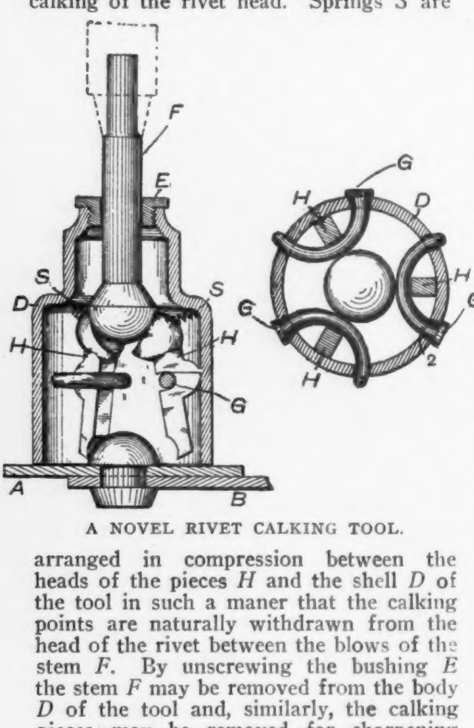
The adoption of the best system for India was a matter of much consequence. Electricity is nowadays the great principle of power, and, as there are systems in operation at home in which it is used, Sir Wolfe Barry inspected the apparatus for operating points and signals, now under trial by the London and Northwestern Railway at Crewe, and the Westinghouse electro-pneumatic system, which is applied to the goods yards at Newcastle on the Northeastern Railway and at Bishopsgate goods yard on the Great Eastern Railway. He rejected both. The mechanism is elaborate and delicate and with the comparatively rough treatment it would get from the ordinary Indian operator, it would soon get out of order, and possibly collaspe. Besides, there is no electric installation at Adra or Santragachi, and its necessity might not arise for some years. Sir Wolfe Barry, therefore, fell back upon the purely pneumatic system which has given such good results at the important station at Salisbury on the London and Southwestern Railway. This system has the great merits of simplicity and strength, and can be maintained and repaired by the ordinary mechanic. Further, the air pressure being lower, there is less liability to loss of pressure from leakage due to the settlement of pipes or other causes. He accordingly recommended the adoption of the pneumatic system, selecting the tender of the British Pneumatic Company for approbation. The board has accepted the proposals, and advised their agent accordingly. The cost of installing the system at Kharagpur, Santragachi and Adra will be £29,250, or only about £5,000 more than the cheapest manual system. Considering the increase of efficiency the slight extra expenditure represents, we do not anticipate any opposition to the scheme on the part of the Government of India.—*Indian Engineering* (India).

A Rivet Calking Tool.

A tool for use in calking rivet heads in steam boiler or tank work has been invented by Patrick J. Sweeney, of Elizabeth. A recent issue of the *Engineer* contained an outline drawing of it, together with a brief description, both of which are given herewith through the courtesy of the *Engineer*.

Here *A* and *B* are the plates secured by the rivet shown, the head of which rivet

is calked by placing the tool centrally over it. The stem *F* of the tool may be inserted in the plunger of a pneumatic riveting hammer and thus caused to deliver rapid blows of its convex head upon the concave heads of the calking pieces *H*. These calking pieces are pivoted upon the bent pins *G* most clearly shown in the plan view. The lower ends of these calkers are suitably shaped for their work and are forced against the head of the rivet by the outward movement of the upper end under the blows of the stem *F*. The rapid succession of blows delivered while the body of the tool is gradually rotated is designed to effect a very quick calking of the rivet head. Springs *S* are



A NOVEL RIVET CALKING TOOL.

arranged in compression between the heads of the pieces *H* and the shell *D* of the tool in such a maner that the calking points are naturally withdrawn from the head of the rivet between the blows of the stem *F*. By unscrewing the bushing *E* the stem *F* may be removed from the body *D* of the tool and, similarly, the calking pieces may be removed for sharpening or renewal by drawing out the bent retaining pins *G*. These pins *G* are held in place by split pins inserted through holes drilled in their small ends and have nothing to do, further than to retain the calking pieces in position, the pressure due to blows of the stem being taken directly by the shell *D*.

A Portable Pneumatic Tool Outfit for Railroads.*

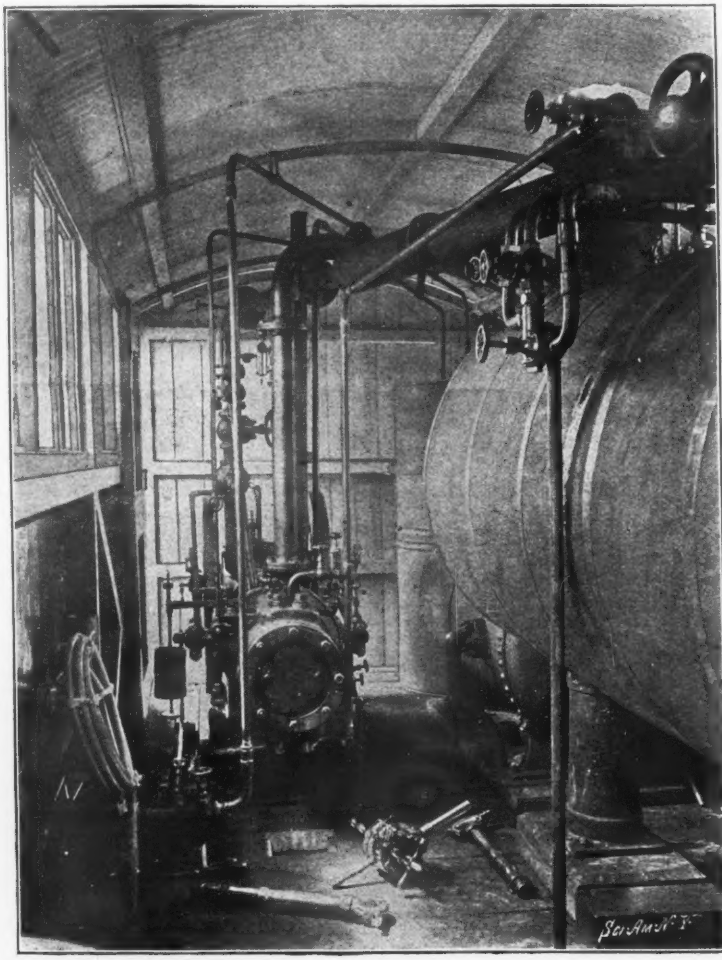
A compact and well-equipped complete portable pneumatic tool installation has recently been designed for the Great Southern & Western Railroad of Ireland by the International Pneumatic Tool Company. There are many phases of work and repairs upon a railroad for which such a pneumatic outfit is peculiarly adapted, notably the repair of bridges, relaying of the rails, and drilling operations, which can be more expeditiously and economically carried out by the aid of pneumatic tools than by the ordinary means of manual labor. The only difficulty in such work is the provision of the necessary air-compressing plant to operate the tools. The Great Southern & Western Railroad have had the car which we illustrate herewith specially constructed and fitted up with a complete installation necessary for emergency purposes.

The power for driving the air-compressing plant comprises a 12-horse-power semi-portable boiler, complete with steam injector and the other necessary fittings. The air compressor is of the horizontal straight-line, steam-driven type, with water jacket and automatic speed and pressure regulators, and it has a capacity of 134 cubic feet of free air per minute. This part of the plant is mounted on a sub-base fixed on the floor of the truck. Beneath the floor of the wagon is suspended a steel air tank. This reservoir is 6 feet in length by 2 feet 6 inches diameter, and is fitted with a flexible hose. The plant in the wagon itself also comprises a water-circulating tank, which for economy of space and weight fulfills a dual purpose—cooling the air-compressing cylinder and feed-water tank for the steam engine boiler. The pneumatic tools provided with the plant consist of two long-stroke hammers capable of closing down rivets of one inch diameter, and two pneumatic holders for use with them; two No. 2 "Little Giant" drills for boring holes up to 1¼ inches diameter, several lengths of ½-inch metallic covered flexible hose, to enable the tools to be operated at a

* Published in the Scientific American from its English correspondent. Illustrations supplied through the courtesy of the *Scientific American*.

distance from the vehicle, air filters, air-cocks, hose-clips, etc. The plant, which has been in operation for some weeks, has proved a great benefit for general and temporary work, both in the saving of labor, the expedition of the work in

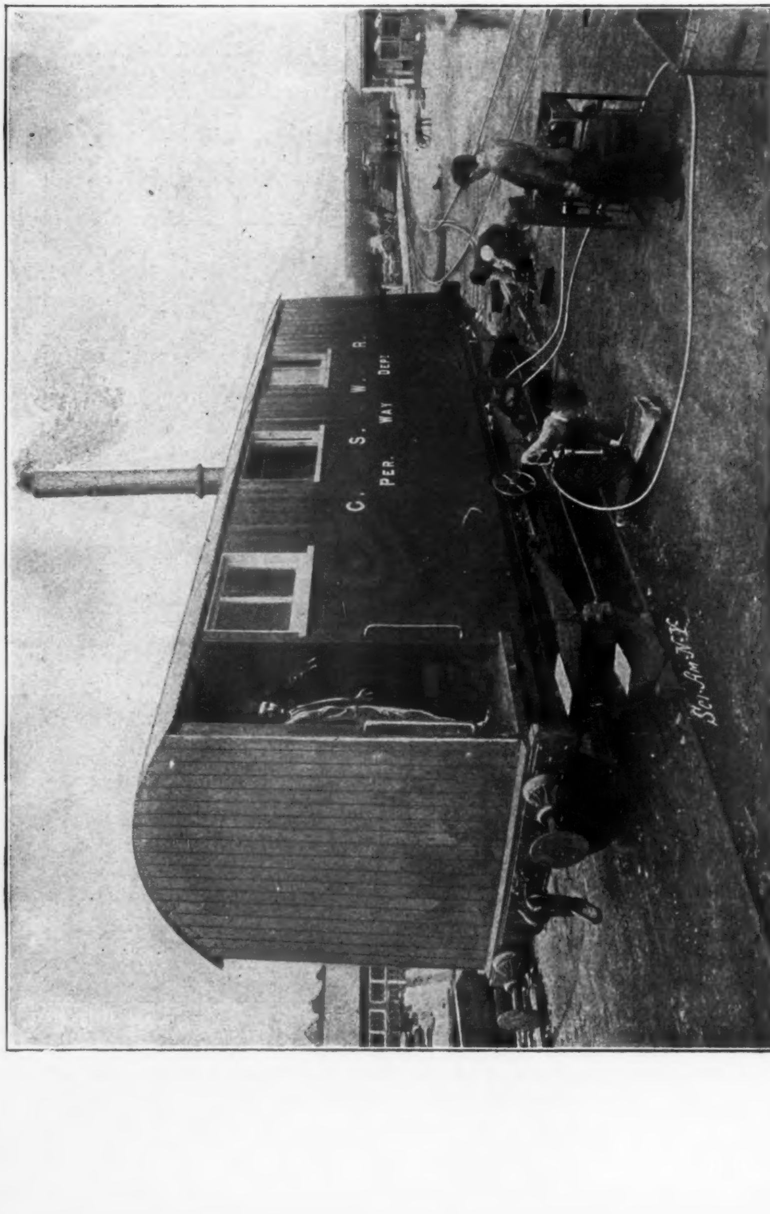
Such installations are useful in sparsely populated countries like Ireland, where either labor is difficult to obtain, or the repairs have to be carried out some distance from a center of population. The wagon containing the installation can be



INTERIOR OF THE REPAIR-CAR, EQUIPPED WITH PNEUMATIC TOOLS.

hand, and cheapening of the cost of repairing. In our illustration the plant is shown in use for bridge-repairing work, for which it is most eminently suited.

rapidly conveyed to the spot, and the air compressor can be set in working order en route, so that it is possible to commence operations directly the structure in need of repair is reached.



A PORTABLE PNEUMATIC TOOL OUTFIT FOR USE IN RAILWAY-BRIDGE REPAIRING.

Notes.

The South Yorkshire Vacuum Cleaner Co., Ltd., has been registered in England with a capital of £1500. This company will carry on a business as carpet and general cleaners by the vacuum method.

The Cloud Marple Pneumatic Tool Manufacturing Company has been incorporated under the laws of New Jersey with a capital stock of $100,000. The incorporators are J. D. Cloud and Joel Marple, of Philadelphia, and Frank P. McDermitt, of Jersey City.

In the report of Second Assistant Postmaster Shallenberger, it was stated that routes were planned for a pneumatic mail tube service in New York, that the cost of construction had been estimated and plans were being made for financing the work. There are now several other lines which are in operation and this plan includes a more elaborate and complete service.

The Pullman Company have been getting all sorts of notoriety through the statements made by one of its officers that the blankets in the Pullman cars were only washed twice a year. In explanation of this statement it has since been brought out that after every trip the blankets are taken out of the car and thoroughly blown out with compressed air at 90 pounds pressure.

The control of the underground system of freight transportation for Chicago has passed into the hands of the Illinois Tunnel Company, which has been recently incorporated. In addition to gaining control of the present conduit under the streets of Chicago, this company plans to develop a particularly elaborate system of tunnels. It also will control the pneumatic tube system for conveying parcels which is now being installed.

Compressed air has been figuring in the municipal legislation of San Francisco. An ordinance was introduced in that city prohibiting the use of machinery in the streets for cleaning carpets and furniture by compressed air. This question was referred to the Merchants' Association, which reported back that this machinery was being used in Los Angeles, Portland, Milwaukee, Chicago, Springfield, Ill.; Denver or Colorado Springs, and was not considered objectionable in any of these places.

The American Air Tool Company, of Dunkirk, N. Y., has been incorporated and has elected the following officers: President, Robert J. Gross, second vice-president of the American Locomotive Company; vice-president and general manager, F. W. Smith, who holds a similar position with the United Radiator Company; secretary and treasurer, L. M. Murray. The company will manufacture pneumatic tools and machinery and carriage and wagon axles. The capital stock is $300,000.

In an article entitled "Oil Fire Furnaces," by A. M. Bell, M. I. M. E., in the November number of *Cassier's Magazine*, an application of compressed air for an oil heater is noticed. This furnace is for tube welding, bracing, annealing and type setting, and is constructed very compactly and in convenient form. A burner operated by compressed air is placed vertically at the foot of the combustive chamber and the heated gases are conducted horizontally across the opening provided for the tube end to be welded. A total of 100 tube ends per hour can, it is said, be secured.

Mr. H. F. J. Porter, who has been associated with Westinghouse interests since the first of last year, and has held the position of assistant manager of the Publishing Department, with offices in East Pittsburg and 10 Bridge street, New York, has been made second vice-president of the Nernst Lamp Company, of which enterprise Mr. George Westinghouse is president, with the duties of general manager and headquarters at Pittsburg. He assumed charge on December 1.

This appointment does not affect Mr. Porter's relations with the Publishing Department at the present time.

Several inventions which apply to compressed air machinery have recently been patented in England. Among them

is a valve which is operated by the piston of an air compressor automatically and positively against the power of a spring by a projection on a connecting rod which reciprocates the piston. Another relates to air compressors in which the compound steam and air cylinders are arranged in tandem and connected by a common crank shaft. In this case the steam cylinders are controlled by balanced valves, and the air cylinders by piston valves, both operating directly upon the crank shaft, the air valves being placed laterally and obliquely on the air cylinders.

A new company to deal in compressed air machinery has just been incorporated in Connecticut. It is known as the George Miles Company, and is located at Winsted, Conn. According to the certificate of incorporation, the nature of its business is the manufacture of, selling and dealing in pneumatic specialties, air compressors, elevator drops, tubes, carriers, heaters, boilers, general iron work and business appertaining thereto. The capital stock is $50,000, and the incorporators are George Miles, of Hull, Mass.; Alfred Schoff, of Norfolk; J. Martin Sauter, of Winsted, and Davis J. McSweeney, of South Boston, Mass. No cash has been paid in on the stock, but the certificate or organization states that $20,000 has been paid in on machinery and patents.

The care of pneumatic tools is a subject that merits the attention of all purchasers of these useful appliances. The simplicity of their exterior misleads the observer into believing that they require no attention, whereas they should receive as much care as a sportsman bestows on his favorite gun. A pneumatic hammer must be kept clean and well oiled all the time, like any other high-speed tool or machine. They can be cleaned by using kerosene and should be lubricated only with sewing machine oil or some equivalent having a light body. A well kept pneumatic tool is a valuable apparatus, but one allowed to rust and become gummed with heavy oil and dirt is nothing but a nuisance. The operation of a tool of any sort in the latter condition is something no maker will guarantee.—*Engineering Record.*

The United Stated Circuit Court of Appeals has reversed the decree of the lower court in the suit of the American Compressed Air Cleaning Company, owning the Nation patent, vs. the Wisconsin Compressed Air House Cleaning Company, operating under the Thurman compressed air carpet renovating patents. The latter firm was defended by the licensor, the General Compressed Air House Cleaning Company, of St. Louis, Mo. The Court in reversing the decree granted a victory for the Thurman compressed air carpet renovators. The Court defined the Nation device as a "duster" without patentable novelty and the Thurman machine as a distinct device with characteristics peculiarly its own being a compressed air carpet renovator. This litigation has been in progress for about two years and has undoubtedly had its effect on the general use of compressed air cleaning machinery.

The manner in which the equipment of the Russian railways with American air brakes received its greatest impetus has not been widely known, and may be of interest.

A very serious accident occurred on one of the Russian State railways about the year 1895, when a hand-braked train ran into and telescoped a train that was standing on the track ahead of it, thereby killing several people, and doing a great deal of damage. At that time it was the custom of the Government Railway Department to equip only their passenger trains with the air brake, leaving the freight brakes to be applied by hand. In course of the inquiry that followed this freight train disaster, the Emperor asked the Minister of Ways and Communications to explain how it had happened, and that official stated that if the freight service also had been equipped with American automatic air brakes, the accident would not have occurred. To this the Emperor replied: "Why were they not so equipped?"

Such a reply from that Monarch was equivalent to a command; all the previous troubles in the way of lack of funds were speedily put to the vanishing test, and a Commission was formed from the Ministry of Ways and Communications to study up and recommend the best automatic air brake.

After some time this Commission decided to put to the test five companies who were competing for the five year contract for $7,000,000 worth of brakes which the Government needed at that time. They consequently invited each company to send equipments for a fifty car train, which was to be equipped with each type of brake in turn, and put through the same series of tests. As a result, the Westinghouse air brake was chosen, and as the Government contract stated that the brakes should be made in Russia, a Westinghouse factory was at once started at St. Petersburg. From the day that the report of the Commission was accepted to this, the Westinghouse Company has supplied all the railway brakes for the Russian Government. A statement was recently made that a large order for locomotive brakes had been given to a competing American concern, but this is erroneous. The order was for 1,000 sets of Westinghouse locomotive brakes. The policy of the Russian Government demands that all material which is to be used in connection with Government contracts must be made in Russia by a Russian company. There is no other Russian brake company in existence at the present time than the Westinghouse; none other has received a charter.

Many of the older readers of *Engineering News* will recall from their student days the illustration of a diving-bell in the old text-books on physics or "Natural Philosophy," as it was then called. The illustration showed a small craft floating on the surface of a body of water with a bell suspended from it, which looked as if it had been borrowed from a church steeple. On supports inside the bell were perched two or three persons of diminutive size, in highly uncomfortable attitudes. It is a long step from such a device to the large and elaorate "diving-bell" structure or suspended caisson used in building the Kiel dry docks, which we describe and illustrate in this issue.

It is sometimes said that the modern pneumatic caisson illustrates the principle of the diving-bell. So far as the pneumatic action is concerned this is true. The caisson, however, in all ordinary circumstances rests on the bottom, and is forced down as the work of excavation proceeds, while the true diving-bell is suspended from the surface. The Kiel caisson was thus suspended, and it is, therefore, a true application of the diving-bell. It served purely for purposes of construction and formed no part of the completed structure, as does the ordinary pneumatic caisson.

The conditions which led to the use of the suspended caisson at Kiel are rather peculiar. The docks are located partly in open water; construction "in the dry" by damming off the site was practically impossible, and the diving-bell was adopted as the sole remaining expedient for carrying out the work without concreting under water.

In respect to the method adopted, the Kiel docks contrast with the Kobe dry dock, whose construction was described in our issue of September 24, 1903. The characteristics of location and physical conditions are quite similar in the two cases, except that the Kobe dock required thorough piling to secure a satisfactory foundation, while at Kiel a natural foundation could be had; on the other hand, the Kiel docks are much larger than the Japanese structure. The Japanese engineers chose the plan of surrounding the site with a cofferdam, so as to work in the dry, if it proved possible. Yet the event forced them to do most of the work under water, depositing the concrete by the bucketful. The Kiel suspended caisson avoids this undesirable feature, and in the matter of expense it substitutes the cost of the caisson (minus the salvage) for the cost of the cofferdam. Moreover, the cofferdam must in most cases inclose the entire work; the suspended caisson need be only part of the size of the dock. As the size of the work increases, therefore, not only the uncertainty but also the cost of the cofferdam method increases as compared with the other method. On the whole, the suspended caisson seems the more satisfactory expedient; certainly it is a neater and safer system. The Kiel caisson, with its carefully developed details and its successful operation, will undoubtedly serve as a model for future cases of difficult subaqueous work.—*Engineering News.*

(The article referred to in the first paragraph will be republished in the February issue of COMPRESSED AIR.—Ed.)

INDEX.

U.S. PATENTS GRANTED NOV., 1903.

Specially prepared for COMPRESSED AIR.

742,819. PNEUMATIC-TUBE CARRIER. Maurice Anderson, Chicago, Ill. Filed Feb. 7, 1902. Serial No. 93,017.

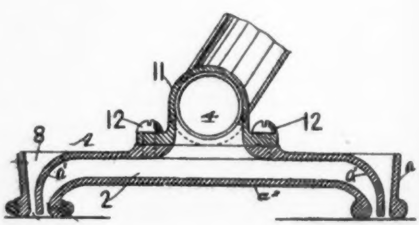
Pneumatic-tube device, comprising a tube formed so that a portion is out of line with the main tube, an opening in the tube at this point through which the carriers are discharged, a detachable supporting-piece associated with said opening and provided with a laterally-projecting part extending outwardly away from the portion of the tube bent out of line, and a valve connected with said laterally-projecting part so as to open outwardly, and a receiving device below said tube connected with said detachable supporting-piece so as to be held in place thereby.

742,831. PNEUMATIC TIRE. John R. Brunt and Richard C. Pitt, Christchurch, New Zealand. Filed Apr. 9, 1902. Serial No. 102,081.

742,834. BRAKE-OPERATING APPARATUS. Louis T. Canfield and John D. Murray, Scranton, Pa. Filed Mar. 29, 1902. Serial No. 100,525.

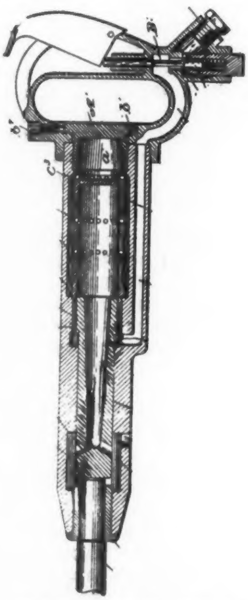
An air-brake system, an air-cylinder, a cylinder-lever provided centrally with a longitudinal slot and in operative connection with the piston rod of the said cylinder, an eccentric supported adjacent to said lever, and provided with a band, a link-bar pivoted to a stationary support and in operative connection with said eccentric-band, a pin or bolt connected with said link-bar and movable in the slot formed in said lever, and means for turning said eccentric, substantially as shown and described.

742,880. PNEUMATIC DEVICE FOR CLEANING CARPETS, FLOORS, OR THE LIKE. Augustus Lotz, San Francisco, Cal., assignor to Sanitary Compressed Air and Suction Dust Removing Company, San Francisco., Cal., a Corporation. Filed Feb. 16, 1903. Serial No. 143,553.



The combination is a pneumatic cleaning apparatus, of a casing inclosing an air chamber, said chamber communicating with a suction discharge-pipe, and having a narrow elongated slit in the bottom, adjacent to the surface passed over by the apparatus, and a wall *a* convergent in relation to the front wall of said chamber, the space between said walls being open at the top and communicating at the bottom through a narrow slit relative to and coincident in length with the opening in the bottom of said chamber.

742,984. FLUID - PRESSURE - OPERATED TOOL. Henry H. Vaughan and Charles H. Johnson, Chicago, Ill. Filed Jan. 14, 1902. Serial No. 89,751.

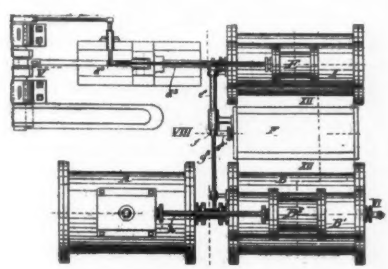


A fluid-pressure-operated tool, the combination with a cylinder, of a reciprocating piston therein, a reservoir, means for charging said reservoir prior to the admission of pressure to the working end of the cylinder and means for connecting said reservoir directly with the working end of the cylinder after the supply has been cut off, substantially as described. A fluid-pressure-operated tool, the combination with a cylinder having an open end, of a bushing fitting within said cylinder and having an exterior diameter less than the interior diameter of the cylinder around the bushing, thereby forming a storage-space between the cylinder and bushing, a partition within said bushing adjacent to one end thereof, a cap having a hollow chamber extending within the open end of said cylinder, said bushing having openings therethrough communicating with said storage-space and said chamber, and a reciprocating piston within the cylinder controlling the supply and discharge of pressure through the openings in the bushing, substantially as described.

743,109. PNEUMATIC-DESPATCH-TUBE SYSTEM. Max Stange, Chicago, Ill. Filed Jan. 17, 1903. Serial No. 139,389.

A pneumatic-tube system, the combination with a despatch-tube and its branch, one of said parts being provided with a longitudinal guide formed in the inner cylindric face thereof and which extends throughout the length of the same and a distance into the other part.

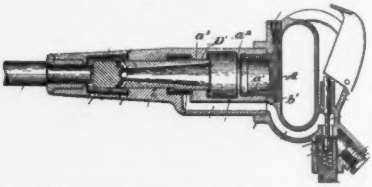
743,326. PNEUMATIC-ENGINE. William E. Peters, Allegheny, Pa. Filed Oct. 14, 1901. Serial No. 78,637.



Apparatus for utilizing an initially-generated power, the combination of a power-generating cylinder and piston, a fluid-actuating cylinder provided with a piston, connected therewith, and a working cylinder and piston, with intervening ports and valves adapted to establish communication between the fluid-actuating cylinder and the working cylinder, means for actuating said valves, consisting of an eccentric and actuating-levers with stems connected therewith adapted to be engaged by the piston of the fluid-actuating cylinder, substantially as set forth. Apparatus for utilizing an initially-generated power, the combination of a fluid-actuating cylinder provided with a reciprocating piston, means for actuating said piston, a working cylinder provided with a piston, a power-shaft and connections therewith from said piston, supply-ports for the working cylinder and valves therefor with eccentric mechanism for shifting said valves, a controlling-valve between the fluid-actuating cylinder and the working cylinder, circulating-ports between said valves and said cylinders, supplemental valves adapted to control the supply of fluid to the working cylinder, and means for actuating said valves consisting of independently-operated lever-shaft and levers, with levers provided with stems adapted to be engaged by the piston of the fluid-actuated cylinder, substantially as set forth.

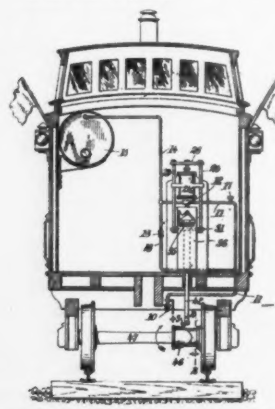
743,356. VALVE DEVICE. Charles H. Watters, Chicago, Ill. Filed Mar. 17, 1903. Serial No. 148,221.

743,389. FLUID - PRESSURE - OPERATED TOOL. Charles H. Johnson, Chicago, Ill. Filed Jan. 14, 1902. Serial No. 89,719.



A fluid-pressure-operated tool, the combination with a cylinder having the bore thereof enlarged to form a supply-chamber and a reservoir, of an annular partition between said reservoir and said supply-chamber, a hollow piston within said cylinder having ports leading from its outer surface to the interior thereof, an imperforate enlargement on said piston of a length greater than the length of said reservoir whereby said reservoir is connected with said supply-chamber prior to the admission of pressure from said supply-chamber through the ports and hollow interior of said piston to the working end of the cylinder.

743,916. AIR-BRAKE ATTACHMENT. Harlon F. Ong, Wendling, Oreg. Filed Sept. 23, 1902. Serial No. 124,513.



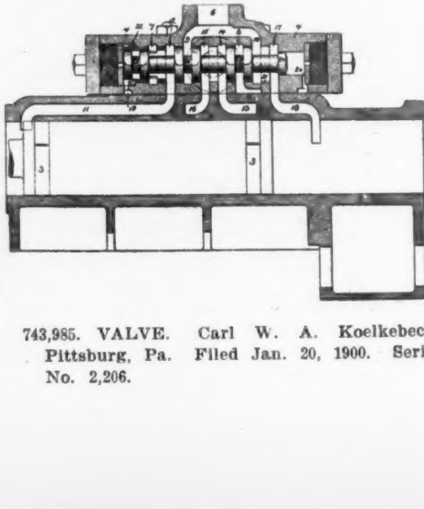
The combination with an air-brake system, of a reservoir, a pipe leading therefrom, two branch pipes communicating with the first-named pipe and with the train-pipe, a check-valve in one of said branch pipes, a valve in the other branch pipe, for the purpose specified, and means for operating the valve, such means comprising a part in connection with a mobile part of the vehicle to which the brake is applied. The combination with a fluid-pressure brake system, of an auxiliary apparatus separate from the brake system and capable of reapplying the brakes, said apparatus comprising a pressure-reservoir, a valve controlling its communication with the train-pipe and the communication of the train-pipe with the atmosphere, two devices for jointly operating the valve, the one of said devices being capable of connection with a mobile part of the vehicle to which the brake is applied, and means controlled by the train-pipe pressure for moving the first-named of said valve-operating devices in and out of connection with said mobile part of the vehicle and for actuating the other valve-operating device.

743,130. MECHANISM FOR ACCENTUATING ONE OR MORE NOTES IN MECHANICALLY-ACTUATED MUSICAL APPARATUS. Francis Young, New York, N. Y., assignor to the Aeolian Company, New York., N. Y., a Corporation of Connecticut. Filed Mar. 14, 1903. Serial No. 147,741.

743,511. VALVE. Charles E. Huxley, Quincy, Ill. Filed May 7, 1902. Serial No. 106,250.

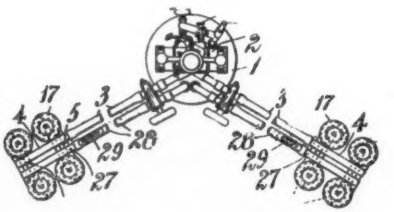
743,920. IMPACT TOOL. Thos. H. Phillips, St. Davids, Pa. Filed Sept. 2, 1902. Serial No. 121,837.

The combination is an impact-tool, of a cylinder, a piston, a valve-chest, a valve, and passages extending from the rear end of the cylinder to the valve-chest, and from the valve-chest to a point some distance from the front end of the cylinder, whereby, when the piston, in its rearward movement, uncovers said forward passage, steam will be permitted to pass directly from the front end of the cylinder to the rear end of the same, independently of any movement of the valve.



743,985. VALVE. Carl W. A. Koelkebeck, Pittsburg, Pa. Filed Jan. 20, 1900. Serial No. 2,206.

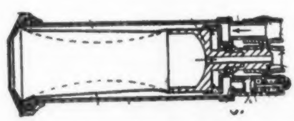
744,188. PNEUMATIC MILKING APPARATUS. Alexander Gillies, Terang, Victoria, Australia. Filed June 16, 1903. Serial No. 161,717.



A pneumatic milking apparatus, a teat-cup, consisting of a rigid casing, a flexible lining therefor, a cup at the bottom of said lining, and a cap and nut for connecting the flexible lining to the cup at the bottom thereof, said cap having a boss adapted to fit into the base of said rigid casing, substantially as described.

744,202. VALVE-GEAR. Franklin W. Jarvis, Chicago, Ill. Filed June 27, 1903. Serial No. 163,313.

744,189. TEAT-CUP FOR PNEUMATIC-MILKING APPARATUS. Alexander Gillies, Terang, Victoria, Australia. Filed June 17, 1903. Serial No. 161,941.



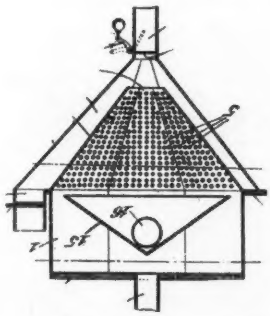
The combination with a teat-cup consisting of a rigid casing having a flexible lining, of an automatic air-inlet valve opening in the space between the lining and the casing, an intermittent suction-pipe at the base of said space, and a continuous suction-pipe at the base of the inner compartment of the teat-cup, substantially as set forth.

744,394. PROCESS OF MAKING SINGLE-TUBE PNEUMATIC TIRES. Theron R. Palmer, Jeannette, Pa. Filed June 11, 1903. Serial No. 161,027.

744,433. VALVE. Lorens Swenson and John S. Swenson, Cresco, Iowa. Filed Apr. 23, 1903. Serial No. 154,015.

744,435. PNEUMATIC TIRE. Irvin Tennant, Springfield, Ohio, assignor to Tennant Auto-Tire Company, Springfield, Ohio, a Corporation of New Jersey. Filed Apr. 17, 1902. Serial No. 103,253.

744,390. PNEUMATIC GRADER. William S. Osborne and Elwin C. Bryant, St. Louis, Mo. Filed July 19, 1901. Serial No. 68,936.

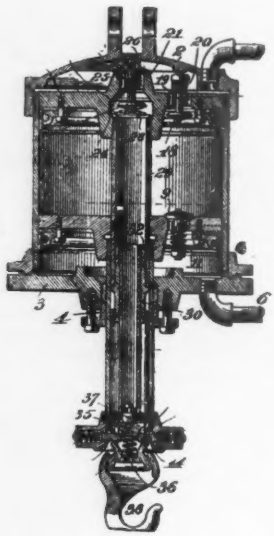


The combination with a casing comprising a surrounding wall, a top wall spanning the space inclosed by said surrounding wall and provided with an inlet-opening for the material to be acted upon, and a perforated, inverted pyramidal portion having its upper portion connected to said surrounding wall and its lower end provided with a discharge-opening, of a pyramidal spreader in said casing with its bottom above said perforated portion and its apex below and in line with said inlet-opening for the material, an imperforate, inverted, pyramidal casing-wall about said perforated portion and spaced therefrom to produce an air-space, said imperforate wall having a discharge-opening at its lower end and said opening at the lower end of said perforated portion discharging into said air-space, an over-balanced valve closing said opening at the lower end of said imperforate wall, means for closing the upper end of said air-space above said perforated portion, an air-inlet leading from atmosphere directly to said air-space, and an eduction-pipe leading from the interior of said pyramidal spreader to a point outside of the apparatus; substantially as described.

744,436. PNEUMATIC TIRE. Irvin Tennant, Springfield, Ohio, assignor to Tennant Auto-Tire Company, Springfield, Ohio, a Corporation of New Jersey. Original application filed June 25, 1903, Serial No. 163,000. Divided and this application filed Aug. 19, 1903. Serial No. 170,019.

744,630. PNEUMATIC TOY. George Schneider, Baltimore, Md., assignor to the George Schneider Manufacturing Company of Baltimore City, a Corporation of Maryland. Filed Feb. 28, 1903. Serial No. 145,489.

744,611. PNEUMATIC HOIST. Charles H. Reeder, St. Louis, Mo. Filed Dec. 8, 1902. Serial No. 134,453.

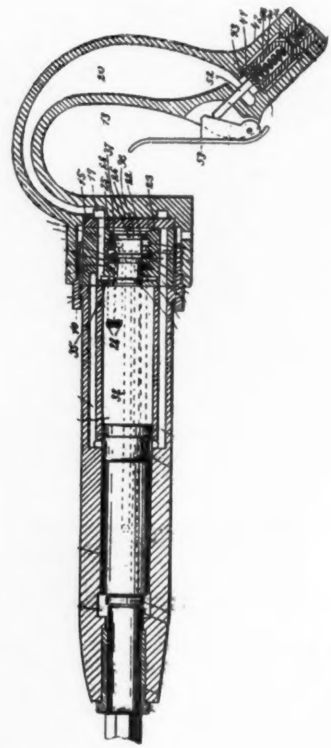


The combination of a cylinder, upper and lower load-lifting pistons arranged to operate in said cylinder, a piston rod carried by said lower piston and a piston-rod carried by said upper piston arranged to operate telescopically in the piston-rod of said lower piston, substantially as set forth.

744,814. PNEUMATIC DESPATCH SYSTEM. Kenneth E. Stuart, Philadelphia, Pa. Filed June 10, 1902. Serial No. 110,972.

A pneumatic-despatch system including two or more stations having selective mechanism adapted to be actuated by selective heads on the carriers for determining the course of the carriers at said stations, the combination of selective fingers forming part of said mechanism and extending into the tube in the path of the carriers to varying distances and at varying distances from the centre of said tube with a system of carriers having selective heads formed with circular finger-engaging faces of varying depth and of varying diameters.

745,239. PNEUMATIC TOOL. Charles B. Richards, Cleveland, Ohio, assignor to the Cleveland Pneumatic Tool Company, Cleveland, Ohio, a Corporation of Ohio. Filed Feb. 20, 1902. Serial No. 94,922.



In a pneumatic tool, the combination with a plunger-cylinder having inlet and exhaust at the outer end and inlet at its inner end and exhaust, a short distance from its inner end, and a plunger reciprocating within said cylinder and formed with an air-distributing groove, of a distributing-valve chamber having one end communicating with the inner end of the cylinder, a distributing-valve in said chamber, and registering ports and channels in the cylinder respectively communicating with the air-supply and with the other end of the valve-chamber to be connected by the groove in the plunger on its outward stroke to admit live air to the other end of the valve-chamber to throw the valve in one direction, the valve

being thrown in the opposite direction by the compression of the air by the returning plunger at the inner end of the cylinder against the valve, substantially as set forth.

744,815. SENDER FOR PNEUMATIC-DESPATCH TUBES. Kenneth E. Stuart, Philadelphia, Pa. Filed July 8, 1902. Serial No. 114,762.

As a sender for pneumatic tubes, a mouthpiece, a sliding gate or gates normally closing said mouthpiece at some distance from its outer edge, means for closing and keeping the gate closed, and a gate-actuating device consisting of one or more inclines extending from the wall of the mouthpiece inward therein to the edge or edges of the gates and serving to open the gates when thrust backward by a carrier.

744,916. FLUID-COMPRESSOR VALVE. Fred. D. Holdsworth, Claremont, N. H., assignor to Sullivan Machine Company, Chicago, Ill., a Corporation of New Hampshire. Filed Aug. 18, 1902. Serial No. 120,084.

In a fluid-compressor, the combination with a valve, of mechanism for moving the same, and yielding means which is both compressible and extensible secured to both said valve and its moving mechanism and forming a connection therebetween, whereby said valve is positively but yieldingly moved in both directions and is governed by the difference in pressure on its faces and irrespective of the position of the moving mechanism.

745,040. PNEUMATIC TIRE. Thomas J. Cooper, Paterson, N. J. Filed Mar. 25, 1903. Serial No. 149,493.

745,099. VALVE. Andrew C. Fambrough, Sonora, Tex., assignor of one-half to Alonzo J. Swearingen, Sonora, Tex. Filed May 12, 1903. Serial No. 156,797.

745,300. MACHINE FOR MAKING PNEUMATIC TIRES. Uzziel P. Smith, Chicago, Ill. Filed Nov. 25, 1902. Serial No. 132,760.